FIRE RISK ASSESSMENT

AT THE FIRESHED LEVEL – PHASE 2

FIRE RISK ASSESSMENT

AT THE FIRESHED LEVEL – PHASE 2

2019

Prepared by the Lebanon Reforestation Initiative **(LRI)**
as part of the Livelihoods in Forestry **(LIF)** project
Funded by the United States Agency for International Development **(USAID)**

This report was developed by:
Dr. Georges Mitri, Director of Land and Natural Resources Program,
Institute of the Environment, University of Balamand

With the contribution of:
Joseph Bechara, Mapping Specialist and Firewise Component Manager, Lebanon Reforestation Initiative

Reviewed by:
Dr. Maya Nehme, Director, Lebanon Reforestation Initiative

Editing and layout:
Anna - Maria Naimeh

How to cite this report:
Mitri, G., Bechara, J., Nehme, M. (2019) "Fire risk brief assessment report of the Fireshed of Qadisha/Abu Ali and Hasbani", Lebanon reforestation Initiative – Livelihoods in Forestry (LiF) project.

*This report is made possible by the support of the American people through the United States Agency for International Development **(USAID)**. The content of this report is the sole responsibility of the Lebanon Reforestation Initiative **(LRI)** and doesn't necessarily reflect the views of USAID or the United States Government.*

Table of Content

List of Figures

List of Tables

Acronyms and abbreviations

asl	Above Sea level
CPC	Corridor Planning Committee
Ha	Hectares
LRI	Lebanon Reforestation Initiative
NPMPLT	National Physical Master Plan of the Lebanese Territory
SLMQ	Sustainable Land management in the Qaraoun catchment project
USAID	United States Agency for International Development
WUI	Wildland-Urban Interface

Background

Firewise is a key component of Fire Adapted Communities – a community collaborative approach that connects all those who play a role in wildfire education, planning, and action with comprehensive resources to help reduce wildfire risk.

More specifically, an adapted Firewise plan for Lebanon mainly consists of reducing wildfire risks and their negative economic, social and ecological impacts on communities by:

- Creating a Firesmart landscape in the wildland/urban interface based on the wildfire risk assessment; and
- Involving the local community (homeowners, landowners, community leaders, firefighters etc.) in the effort to reduce the risk of wildland fires.

This is expected to reduce wildfire risk and its negative economic, social and ecological impacts, increase awareness about wildfires, and help maintain a community-based sustainable forest management.

Starting 2017, Lebanon Reforestation Initiative (LRI) has scaled-up its firewise program usually applied on the village level to the Fireshed level and has set an action plan for the Naher el Kaleb watershed, under the USAID-funded LRI project.

In 2019, LRI planned to replicate this latest experience at the Fireshed level in 2 different watersheds in Lebanon targeting LRI Corridor Planning Committee (CPC) villages in Rashaya and North Lebanon under the USAID-funded Livelihoods in Forestry Project.

Scope of work

The objectives to be addressed in this work were as follows:

1. Identify 2 new firesheds based on the villages of the two previously mapped social and environmental corridors of Rashaya and North.
2. Produce hazard and vulnerability maps at the fireshed level.
3. Develop a fire risk map on the fireshed level, and identify and characterize priority interventions zones for each fireshed.
4. Generate a list of recommendations for fire prevention at priority intervention zones of each selected fireshed.

Methodology of work

The methodology of work was mainly built on the previously designed and developed methodology for assessing fire risk at the fireshed of Naher El Kelb (LRI 2017). The identification of the firesheds involved overlaying previously mapped green corridors (i.e., comprising villages targeted by LRI restoration projects) for connecting forest patches and the fire risk map of Lebanon. More specifically, the two firesheds comprising a higher number of villages crossed by these corridors and at the same time affected by high risk of fires, were selected.

The watershed and administrative maps of Lebanon as employed by the national physical master plan of Lebanese territory (NPMPLT) were used to assist in the delineation of the firesheds. The initial area of the watershed was expanded into a fireshed by annexing external areas of administrative units crossed by the borderline of the watershed. In this context, it is essential to include the full extent of administrative units for efficient and proper implementation of fire risk management tools.

Fire risk will be assessed by producing fire hazard, vulnerability and risk maps of the identified firesheds with the use of satellite imagery. “Priority intervention zones” (i.e., villages of high fire risk) will be identified with the use of the produced fire risk map.

Finally, a list of recommendations will be drafted to assist LRI planning fire prevention measures at priority intervention zones of each selected firesheds.

Identification and description of the two firesheds

The two identified firesheds included the fireshed of Kadisha (i.e., Fireshed 1) and the fireshed of Rashaya (i.e., Fireshed 2). The main topographic characteristics of the two firesheds were presented in the following sections.

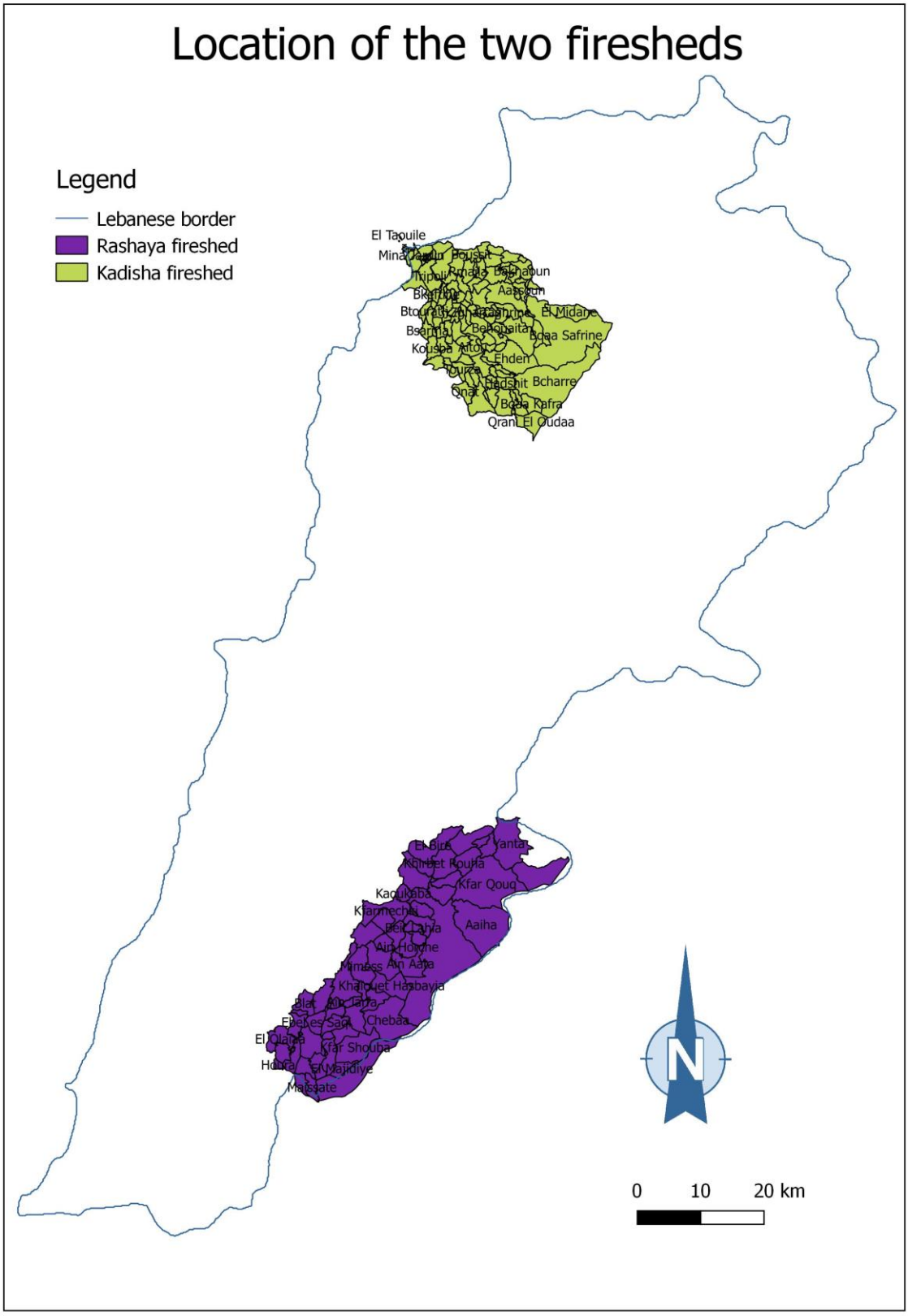


Figure 1. Location of the two firesheds

Fireshed 1: Kadisha fireshed

This fireshed is entirely located in the Mohafazat of North Lebanon. It comprised 5 Cazas namely Minieh-Dannieh, Tripoli, Zgharta, Koura and Bcharreh (**Table 1**). The total area of the fireshed was 58,619.3 ha and it included 134 villages/towns.

Table 1. List of villages/towns of the Kadisha fireshed

Village/town	Caza	Village/town	Caza	Village/town	Caza
Bcharre	Bcharreh	Kfar Chellane	Minieh-Dannieh	Houakir	Zgharta
Maghr el Ahoual	Bcharreh	Kfar Habou	Minieh-Dannieh	Morh Kfar Sghab	Zgharta
Tourza	Bcharreh	Mrah es Sraij	Minieh-Dannieh	Kfar Yachit	Zgharta
Aabdine	Bcharreh	Harf es Siyad	Minieh-Dannieh	Bisbeel	Zgharta
Bane	Bcharreh	Beit Zoud	Minieh-Dannieh	Miziara	Zgharta
Qnaiouer	Bcharreh	El Kharroub	Minieh-Dannieh	Bchannine	Zgharta
Mazraat Ain Baqra	Bcharreh	Haql el Aazime	Minieh-Dannieh	Bneshaai	Zgharta
Wadi Qannoubine	Bcharreh	Beit Hasna	Minieh-Dannieh	Aarjess	Zgharta
Beit Menzer	Bcharreh	Qattine	Minieh-Dannieh	Daraiya	Zgharta
Blaouza	Bcharreh	Aassoun	Minieh-Dannieh	Toula	Zgharta
Hadshit	Bcharreh	Deir Nbouh	Minieh-Dannieh	Mazraat et Teffah	Zgharta
Qnat	Bcharreh	Ketrane	Minieh-Dannieh	Aitou	Zgharta
Hadath ej Joubbe	Bcharreh	Mina 1	Tripoli	Kfarfou	Zgharta
Ed Dimane	Bcharreh	Mina 2	Tripoli	Sibaal	Zgharta
Hasraoun	Bcharreh	Tripoli	Tripoli	Ras Kifa	Zgharta
Bazaoun	Bcharreh	Trablous ez Zeitoun	Tripoli	Karm Sadde	Zgharta
Bqorqacha	Bcharreh	El Qobbe	Tripoli	Ejbaa	Zgharta
Brissat	Bcharreh	Et Tabbaneh	Tripoli	Ehden	Zgharta
Bqaa Kafra	Bcharreh	El Tall	Tripoli	Baslouqit	Zgharta
Qrani El Oudaa	Bcharreh	Ez Zahrieh	Tripoli	Haouqa	Zgharta
El Bqaiaa	Koura	El Hadid	Tripoli	Seraal	Zgharta
Btouratij	Koura	Es Souayqa	Tripoli	Aintourine	Zgharta
Kfar Qabel	Koura	En Nouri	Tripoli	Kfar Sghab	Zgharta
Bsarma	Koura	Er Remmaneh	Tripoli	Majdlaya	Zgharta
Kousba	Koura	El Mhatra	Tripoli	Kafraiya	Zgharta
Rechdibine	Koura	El Haddadine	Tripoli	Boussit	Zgharta

Village/town	Caza	Village/town	Caza	Village/town	Caza
Ras Masqa	Koura	Mina Jardin	Tripoli	Aalma	Zgharta
Bkeftine	Koura	Trablous el Tabbaneh	Tripoli	Hailane	Zgharta
El Midane	Minieh-Dannieh	Mina 3	Tripoli	Aachach	Zgharta
Bqaa Safrine	Minieh-Dannieh	Tourous	Tripoli	Rmaila	Zgharta
Bchennata	Minieh-Dannieh	El Taouile	Tripoli	Meriata	Zgharta
Karm el Mohr	Minieh-Dannieh	Laoukas	Tripoli	Aardat	Zgharta
El Krem	Minieh-Dannieh	Er Rmaile	Tripoli	Kfar Dlaqos	Zgharta
Bchehhara	Minieh-Dannieh	El Mdoura	Tripoli	Meriata	Zgharta
Zghartaghrine	Minieh-Dannieh	El Bellane	Tripoli	Rachaaine	Zgharta
Aaimar	Minieh-Dannieh	El Maksbi	Tripoli	Zgharta	Zgharta
Jarjour	Minieh-Dannieh	El Baqar	Tripoli	Taouahine Ras en Nahr	Zgharta
Kaf el Malloul	Minieh-Dannieh	Kfar Zaina	Zgharta	Kfar Haoura	Zgharta
Qalaat Aaichi	Minieh-Dannieh	Mazraat Jnaid	Zgharta	Et Talle	Zgharta
Behouaita	Minieh-Dannieh	El Khaldiye	Zgharta	Asnoun	Zgharta
El Beddaoui	Minieh-Dannieh	Bchennata	Zgharta	Mazraat Ajbeaa	Zgharta
Tourbol	Minieh-Dannieh	Deir ej Jdaide	Zgharta	Kfar Hata	Zgharta
Aazqai	Minieh-Dannieh	Iaal	Zgharta	Hariq Zgharta	Zgharta
El Quatie	Minieh-Dannieh	Sakhra	Zgharta	Qarah Bach	Zgharta
Bakhaoun	Minieh-Dannieh	Kfar Chakhna	Zgharta		

The Digital Elevation Model (DEM) of the fireshed shows a maximum elevation of approx. 2,809 m above sea level (asl) (**Figure 2**). The slope distribution (in degrees) and the aspect of topography were also presented (**Figure 3** - **Figure 4**). The land cover/land-use map of the fireshed shows the spatial distribution of major land cover/land-use categories, namely, forest, cropland, grassland, urban, road, rivers, surface water bodies, natural land with little vegetation (**Figure 5**).

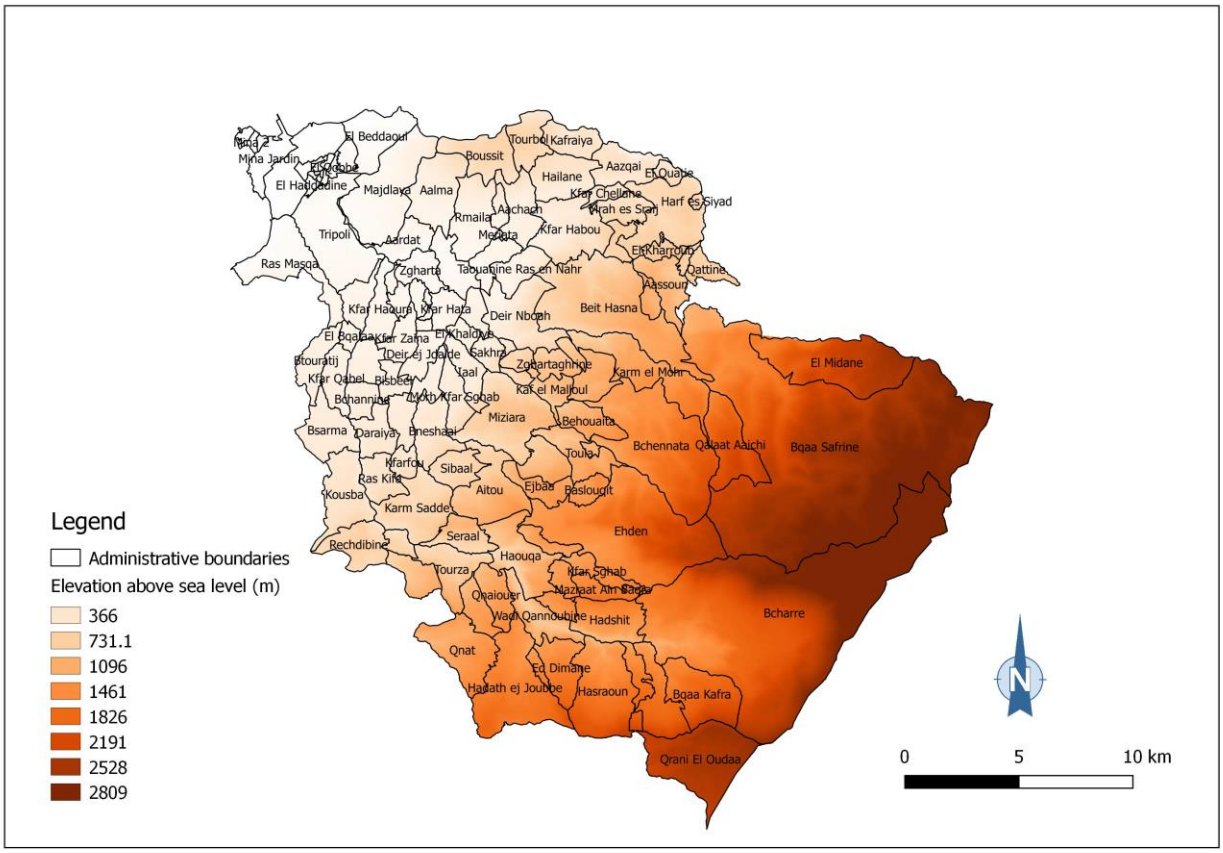


Figure 2. Spatial distribution of elevation the Kadisha fireshed

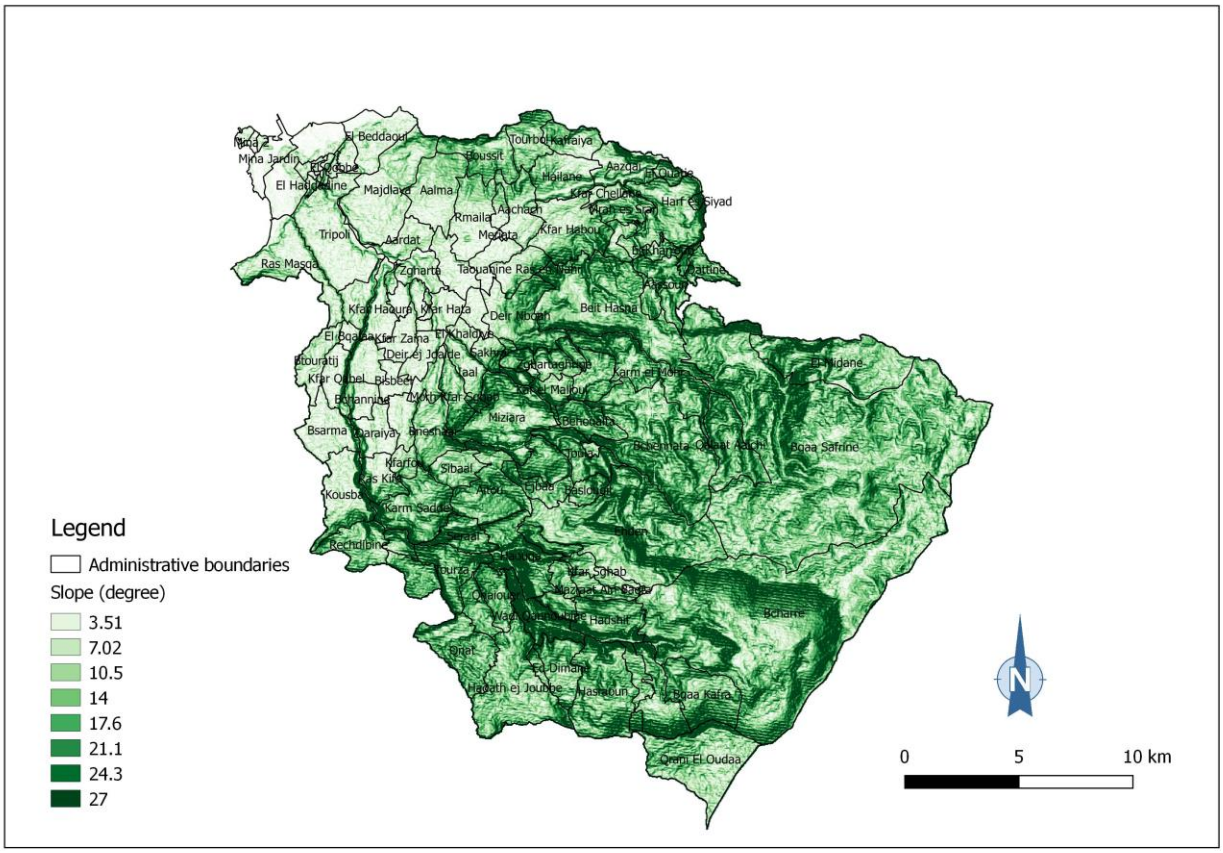
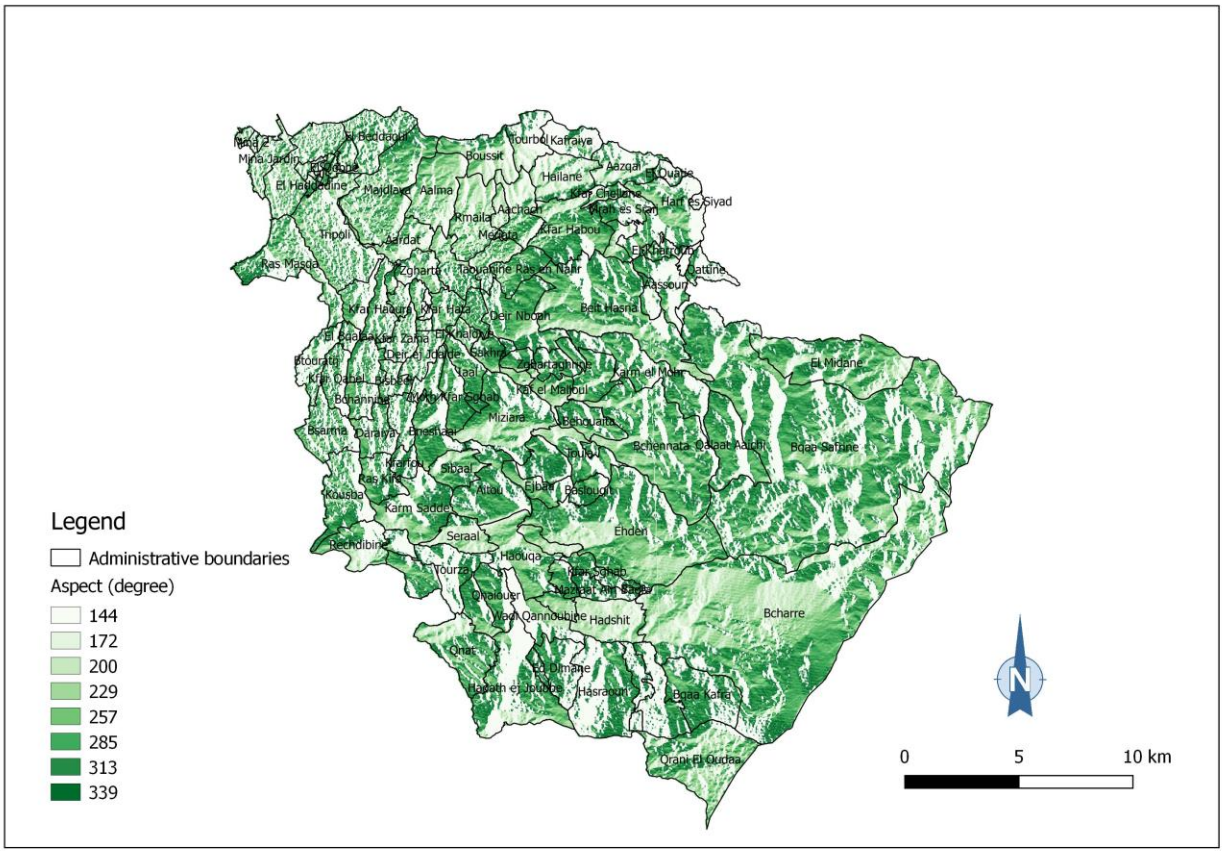


Figure 3.Spatial distribution of slope in the Kadisha fireshed



**Clockwise in degrees from 0 (due north) to 360 (again due north)*

Figure 4. Spatial distribution of aspect in the Kadisha fireshed

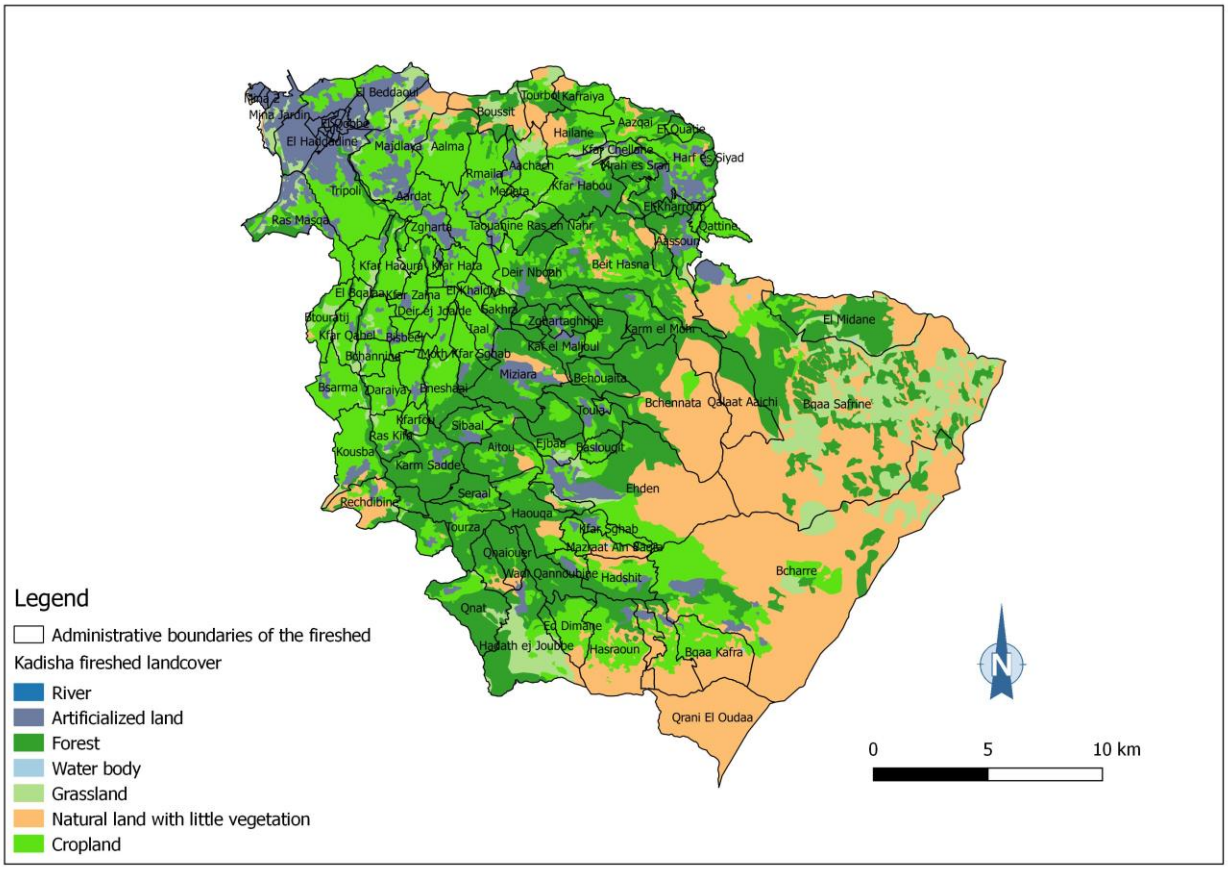


Figure 5. Land cover/land-use of the Kadisha fireshed

Fireshed 2: Rashaya fireshed

This fireshed is located in the Mohafazas of Bekaa and Nabatieh. It comprises 4 Cazas namely Hasbaiya, Marjayoun, Rashaya and West Bekaa (**Table 2**). The total area of the fireshed was 82,409.1 ha and it included 61 villages/towns.

Table 2. List of villages/towns of the Rashaya fireshed

Village/town	Caza	Village/town	Caza
Rachaiya	Rachaiya	El Habbariye	Hasbaiya
Kaoukaba	Rachaiya	Mazarea Chebaa	Hasbaiya
Kfarmechki	Rachaiya	Abou Qamha	Hasbaiya
Ain Horche	Rachaiya	Ain Arab	Marjayoun
El Aakabe	Rachaiya	Slaiyeb	Hasbaiya
Aaiha	Rachaiya	Ain Jarfa	Hasbaiya
Toultata	Rachaiya	Chebaa	Hasbaiya
Marj es Samah	Rachaiya	El Fardis	Hasbaiya
Yanta	Rachaiya	Ebel es Saqi	Marjayoun
El Bire	Rachaiya	Dibbine	Marjayoun
Bakkifa	Rachaiya	Marjayoun	Marjayoun
Mdoukha	Rachaiya	Rachaiya el Foukhar	Hasbaiya
Libbaya	West Bekaa	El Qlaiaa	Marjayoun
Haouch el Qinnaabe	Rachaiya	Kfar Hamam	Hasbaiya
Bakka	Rachaiya	El Qhiyam	Marjayoun
Beit Lahia	Rachaiya	Kfar Shouba	Hasbaiya
Mazraat el Qalioun	Rachaiya	Khreibet Hasbaiya	Hasbaiya
Khirbet Rouha	Rachaiya	Ed Dnaibe	Hasbaiya
Tannoura	Rachaiya	El Meri	Hasbaiya
Ain Aarab	Rachaiya	Borj el Mlouk	Marjayoun
Er Rafid	Rachaiya	Kfair ez Zait	Hasbaiya
El Mhaidthe	Rachaiya	Hasbaiya	Hasbaiya
Kfar Qouq	Rachaiya	Mazraat Sarada	Marjayoun
Ain Aata	Rachaiya	Mimess	Hasbaiya
Deir el Aachayer	Rachaiya	El Khiyam	Marjayoun
Kfardenis	Rachaiya	Houra	Marjayoun
Dahr el Ahmar	Rachaiya	El Majidiye	Hasbaiya
Kaoukaba Hasbaiya	Hasbaiya	Aamra	Marjayoun
Ain Qenia	Hasbaiya	Maissate	Marjayoun
Blat	Marjayoun	Khalouet Hasbayia	Hasbaiya
Chouaiya	Hasbaiya		

Also, the DEM of the fireshed shows a maximum elevation of approx. 1,769 m asl (**Figure 6**). The slope (**Figure 7**) distribution (in degrees) and the aspect (**Figure 8**) of topography were also presented. The land cover/land-use map of the fireshed (**Figure 9**) shows the spatial distribution of major land cover/land-use categories, namely, forest, cropland, grassland, urban, road, rivers, surface water bodies, natural land with little vegetation.

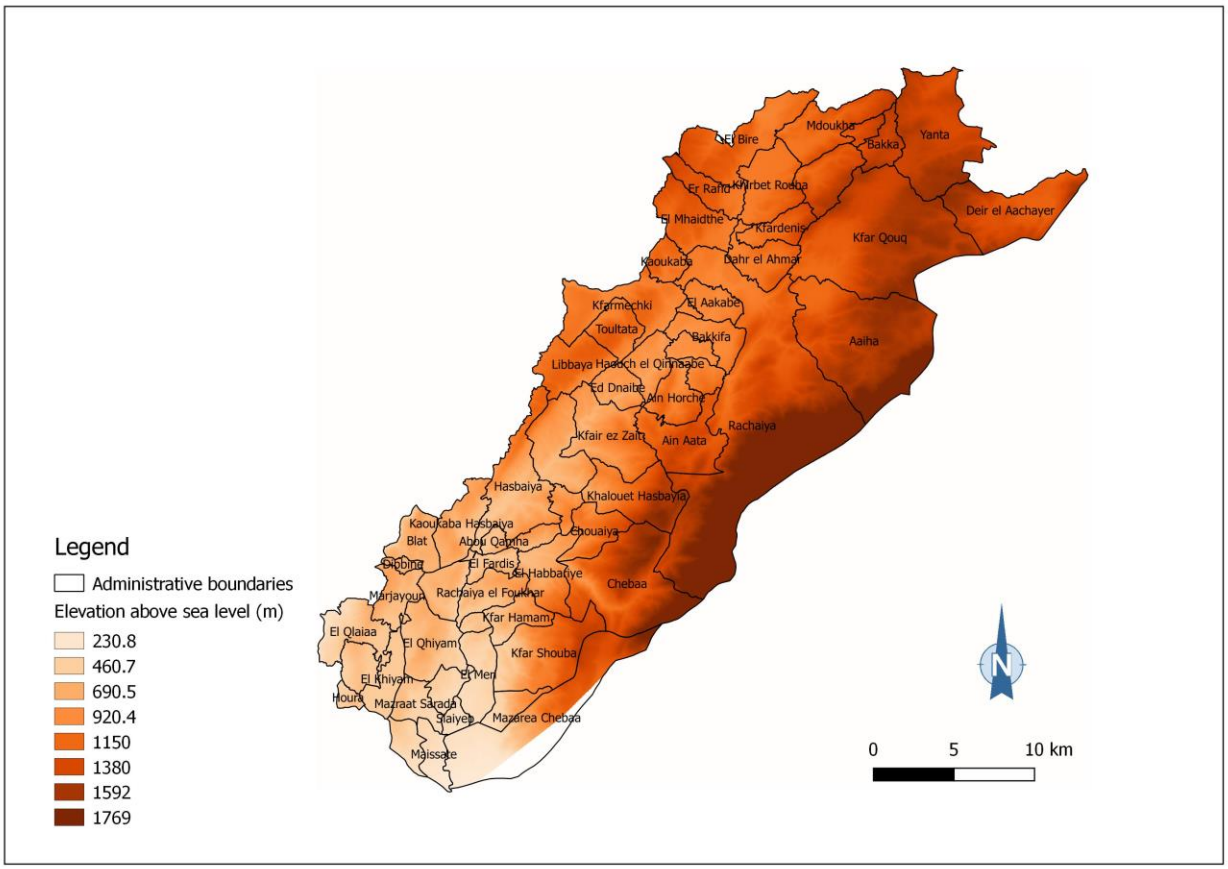


Figure 6. Spatial distribution of elevation the Rashaya fireshed

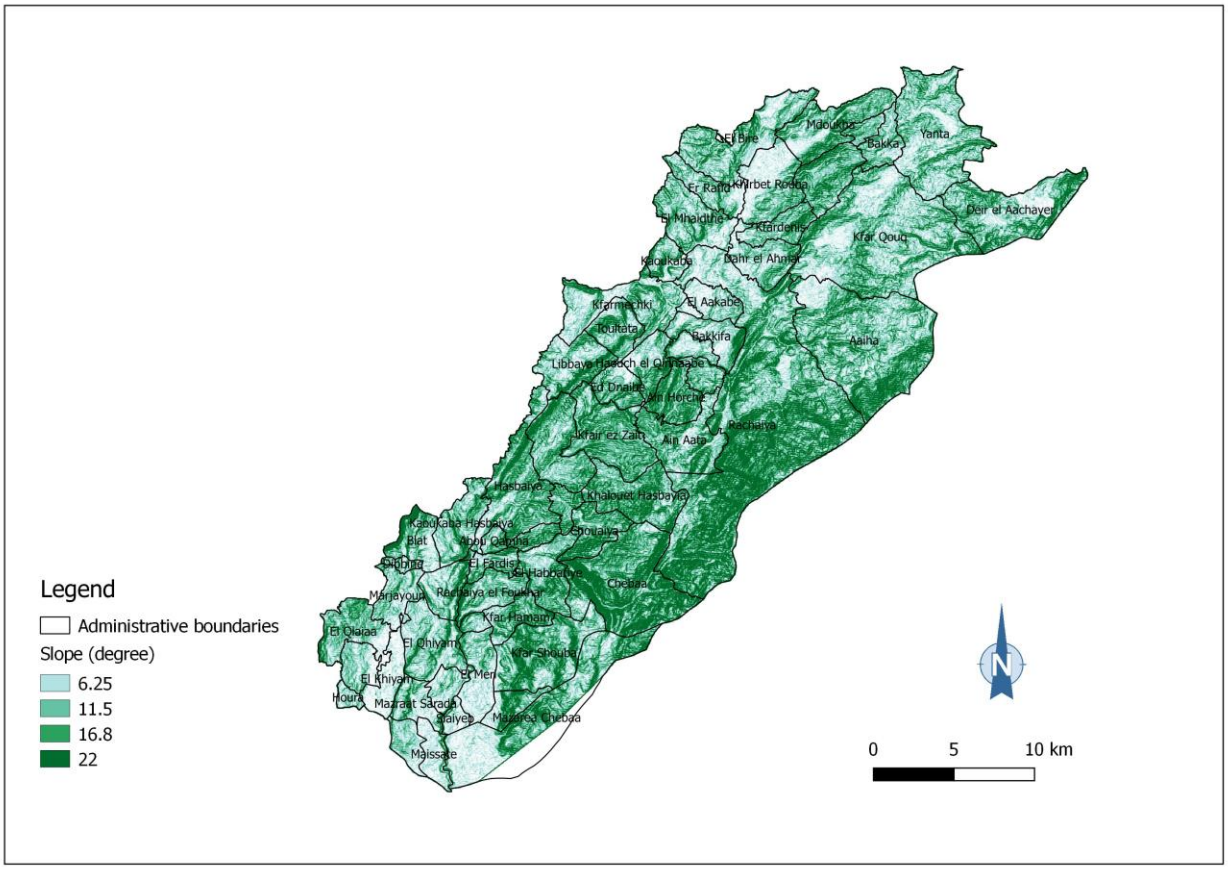
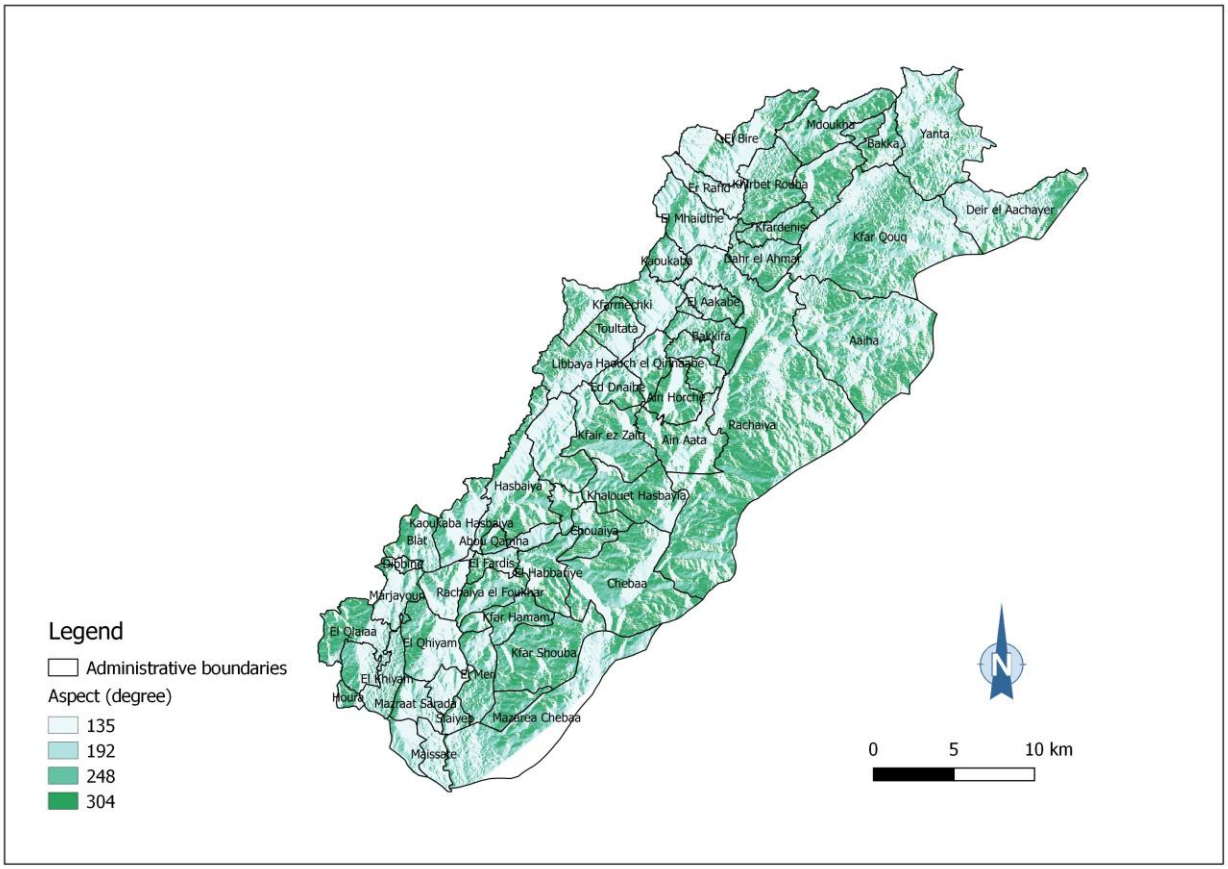


Figure 7. Spatial distribution of slope the Rashaya fireshed



**Clockwise in degrees from 0 (due north) to 360 (again due north)*

Figure 8. Spatial distribution of aspect in the Rashaya fireshed

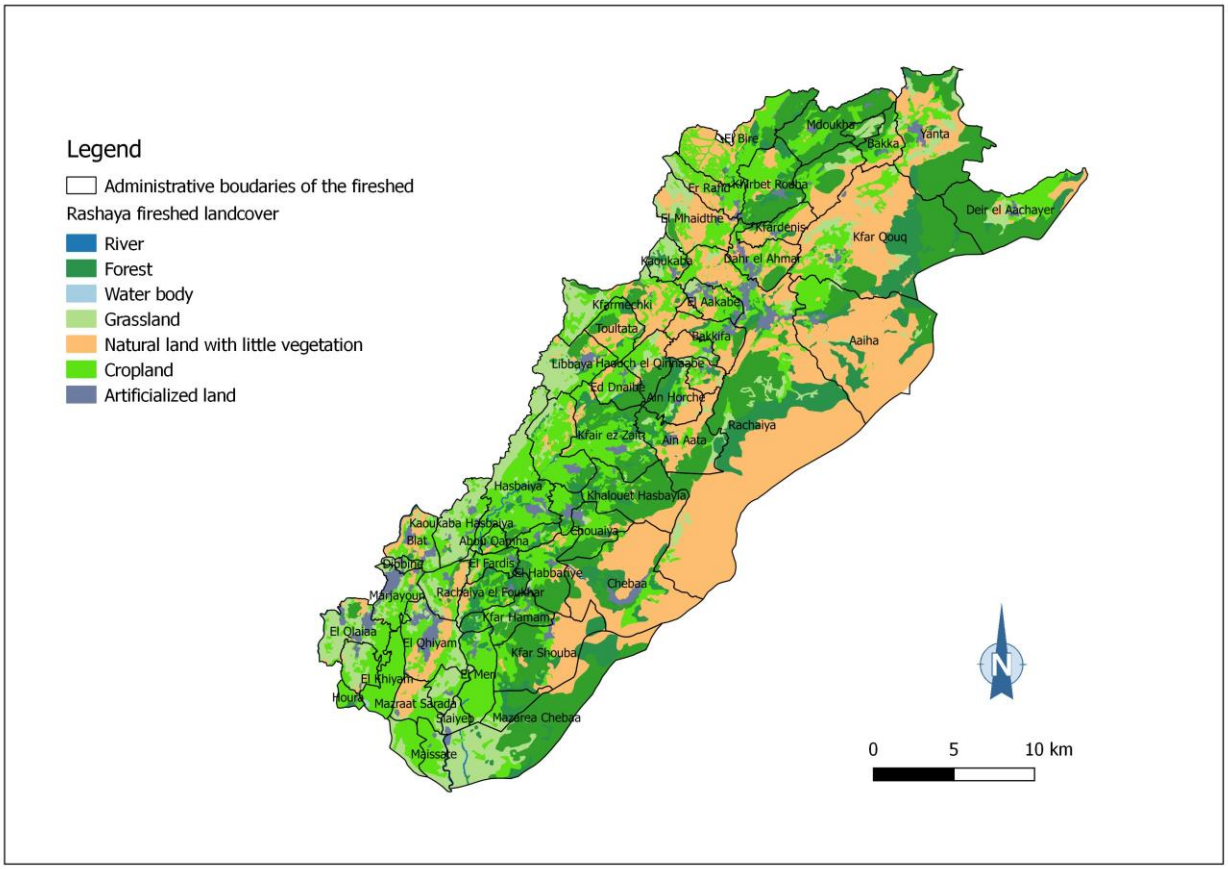


Figure 9. Land cover/land-use of the Rashaya fireshed

Fire risk mapping

An overall wildfire risk assessment was prepared for the fireshed. Fire hazard and vulnerability were considered in this assessment upon data availability and the general characteristics of the site (IOE/UOB/LRI, 2014). Fire risk was assessed as a product of fire hazard and fire vulnerability (Risk = hazard x vulnerability).

Fire hazard assessment involved the use of data mainly related to the distribution and density of forest fuel. This comprised the employment of a recent Sentinel 2-A satellite imagery (10x10 m resolution) acquired on 23-9-2018. Fire vulnerability was assessed at the cadastral unit level (i.e., village as a mapping unit) and in function of the relative area of hazard per mapping unit. This comprised the use of the administrative map showing the boundaries of villages within the fireshed. More specifically, cadastral unit comprising more than 30% of areas classified as high hazard were mapped as high vulnerability. Low vulnerability units comprised high hazard areas less than 10% while moderate vulnerability units comprised high hazard area between 10% and 30%. In addition, villages comprising protected forest areas (e.g., Ehden nature reserve, cedar forest, etc.) were classified as highly vulnerable.

Evaluating fire risk in the area involved the use of a cross mapping between hazard and vulnerability as shown in **Table 3**.

Table 3. Fire risk scoring matrix

Hazard\Vulnerability	High vulnerability	Moderate vulnerability	Low vulnerability
High hazard	High risk	High risk	Moderate risk
Moderate hazard	High risk	Moderate risk	Moderate risk
Low hazard	Moderate risk	Moderate risk	Low risk

A total of three maps were produced, namely a fire hazard map (i.e., low hazard, moderate hazard, and high hazard), a fire vulnerability map (i.e., low vulnerability, moderate vulnerability,

and high vulnerability), and a fire risk map (i.e., low risk, moderate risk, high risk, and very high risk). The different maps and their corresponding statistics are presented in the following sections.

Fire risk mapping in Fireshed 1 (Kadisha)

Initially, a fire hazard map (**Figure 10**), a fire vulnerability map (**Figure 12**) and a fire risk map (**Figure 14**) were produced for Fireshed 1. Statistics on extent of the different classes associated with these maps, i.e., hazard (**Figure 11**) vulnerability (**Figure 13**) and risk (**Figure 15**), were also presented. More specifically it was observed that high hazard areas covered around 18% of the total area of the fireshed. High vulnerability areas covered 45% of the fireshed. Accordingly, high fire risk covered around 28% of the fireshed.

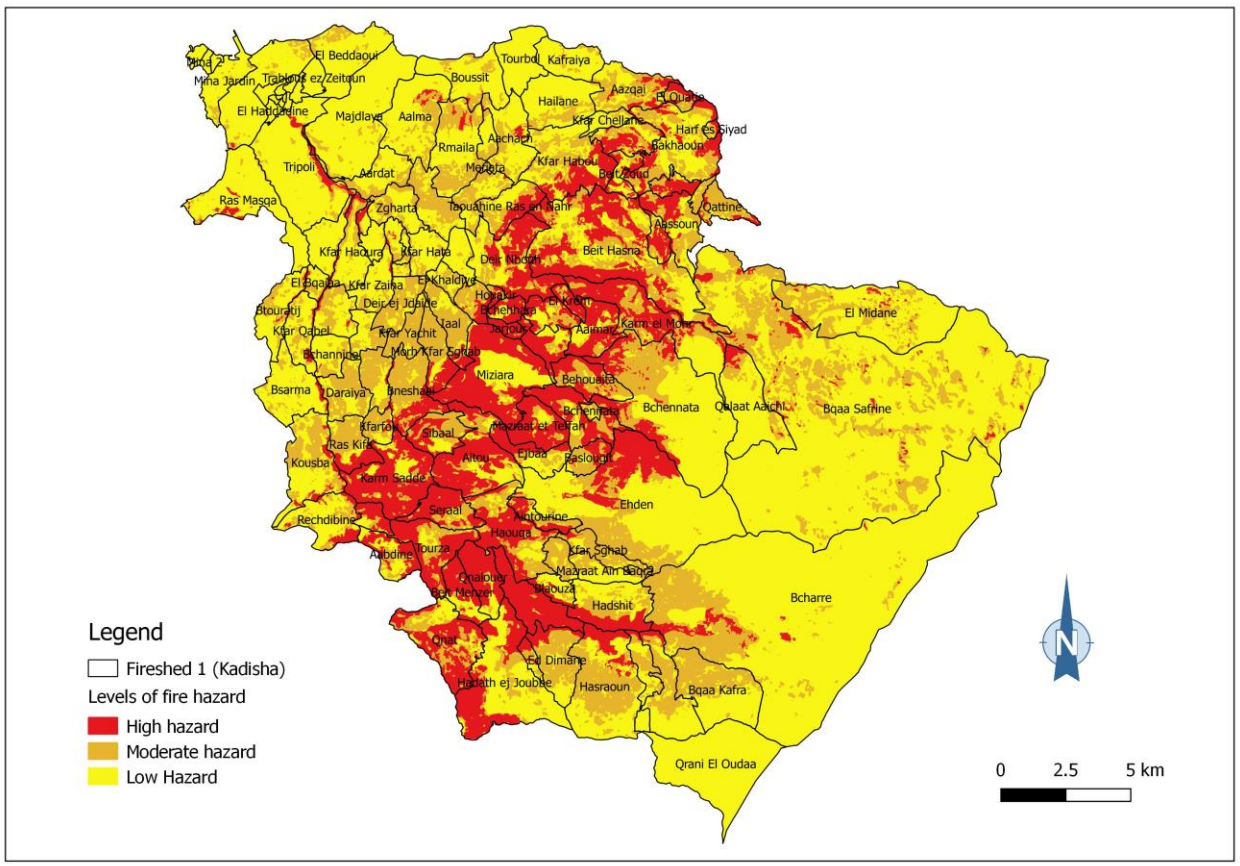


Figure 10. Fire hazard map of Fireshed 1 (Kadisha)

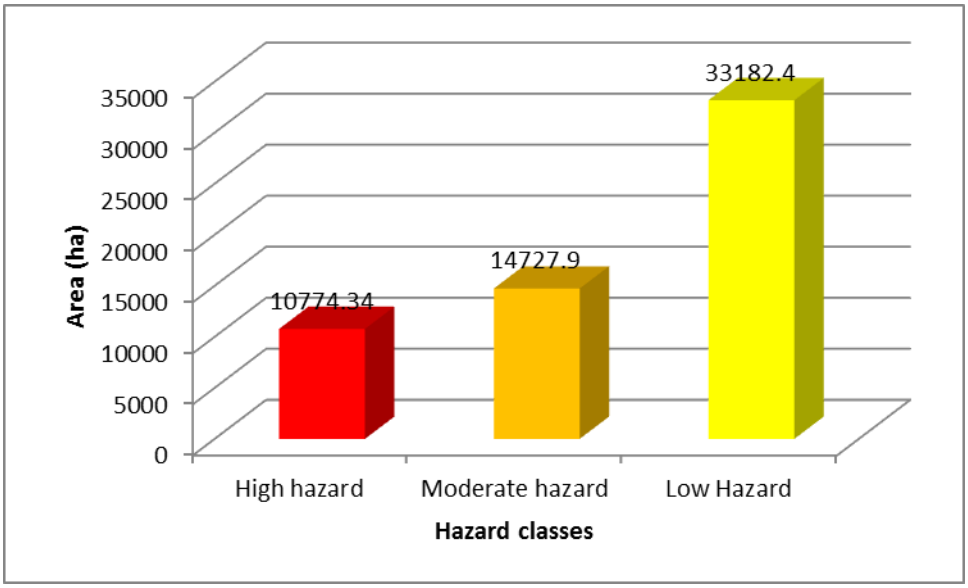


Figure 11. Distribution of hazard classes (Kadisha)

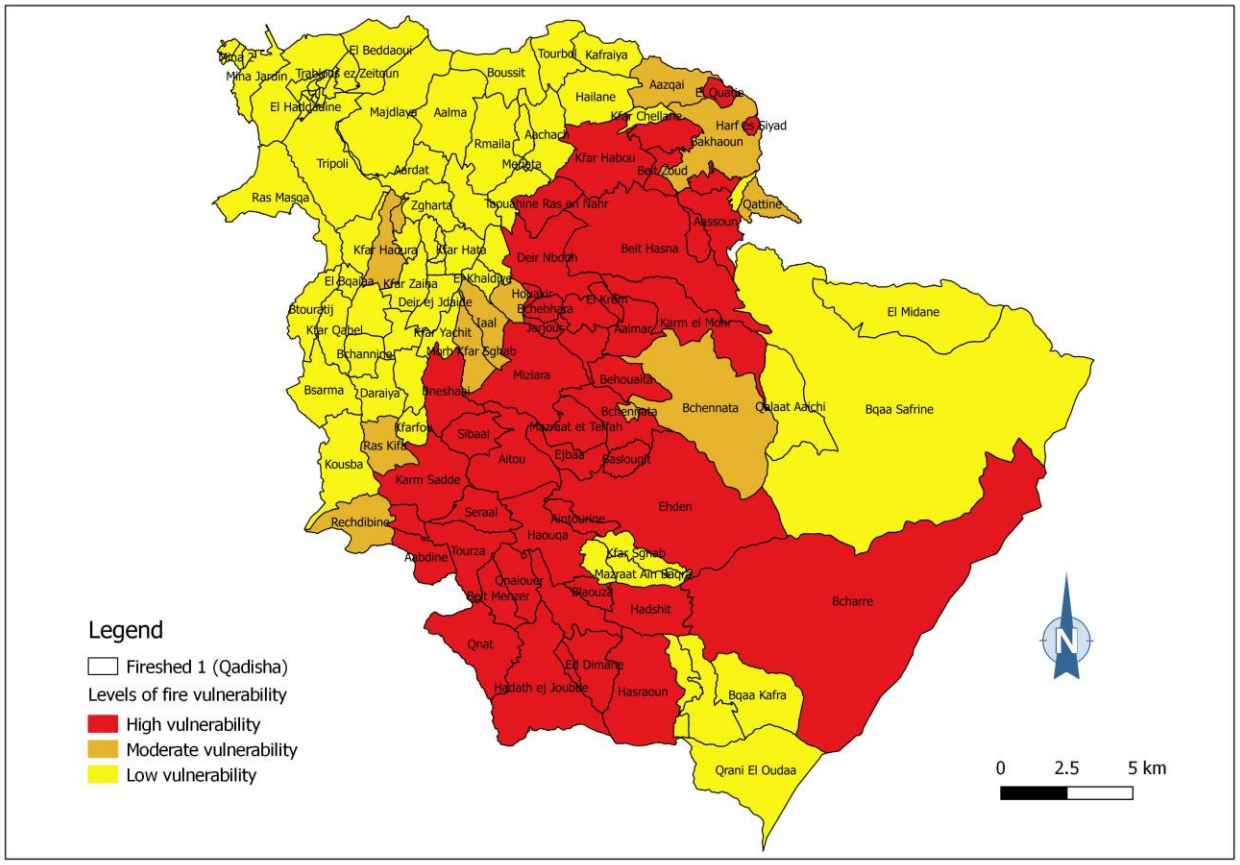


Figure 12. Fire vulnerability map (Kadisha)

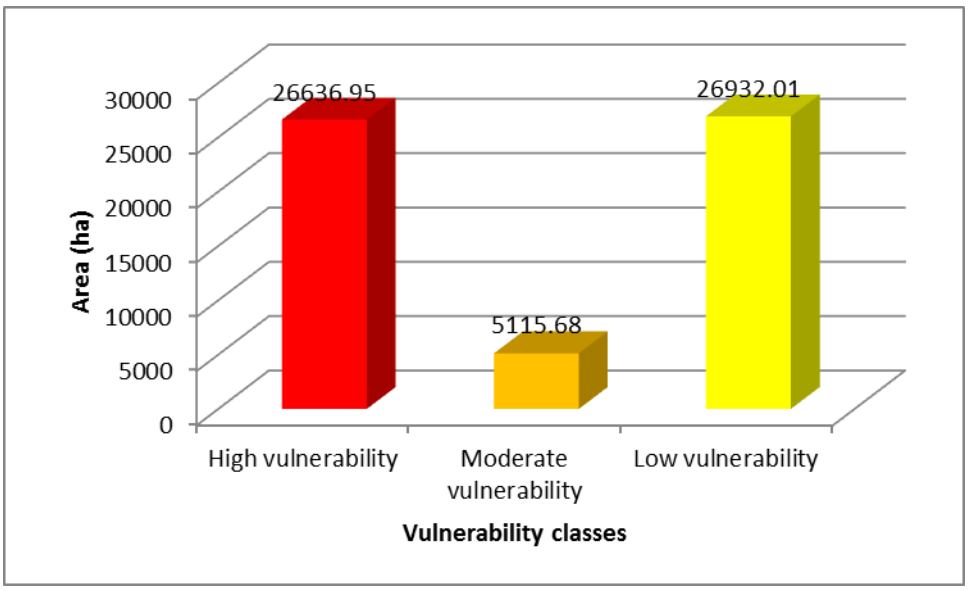


Figure 13. Distribution of vulnerability classes (Kadisha)

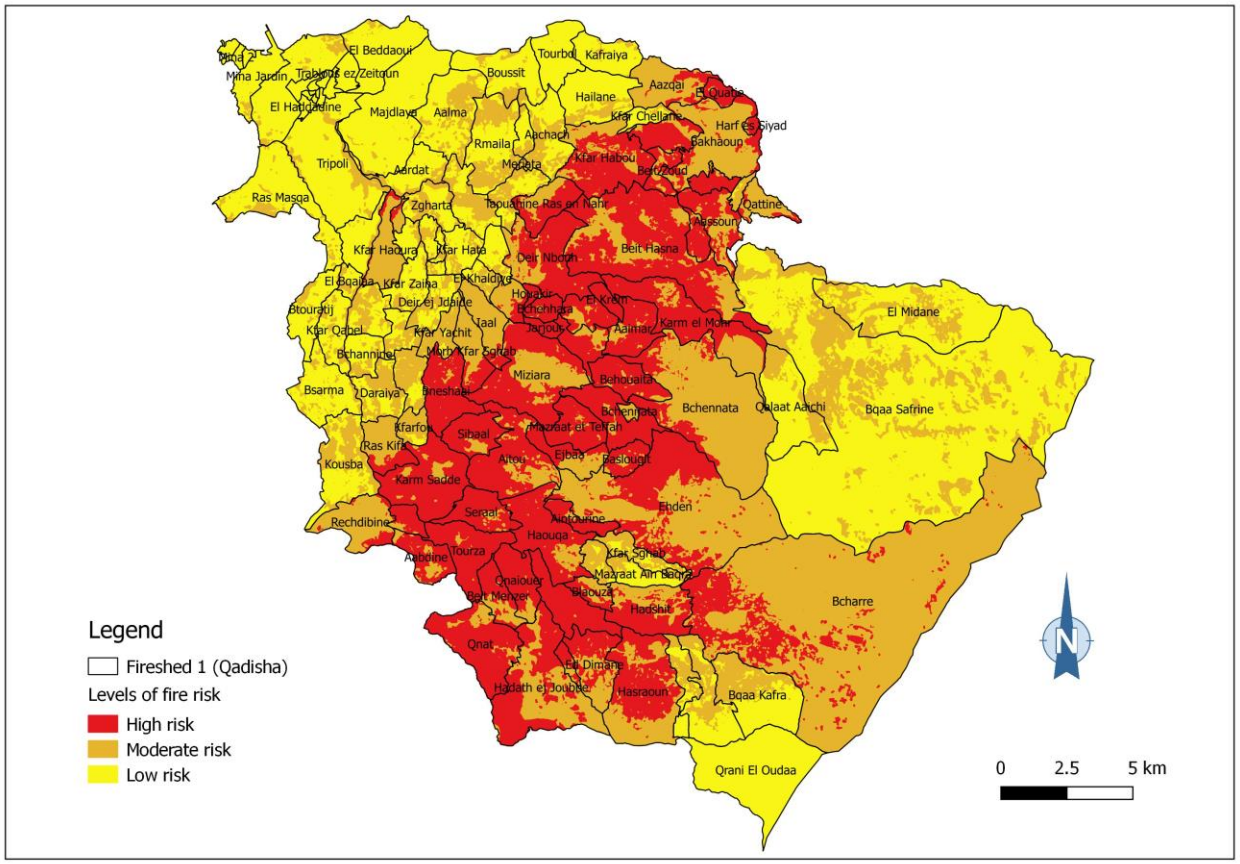


Figure 14. Fire risk map of Fireshed 1 (Kadisha)

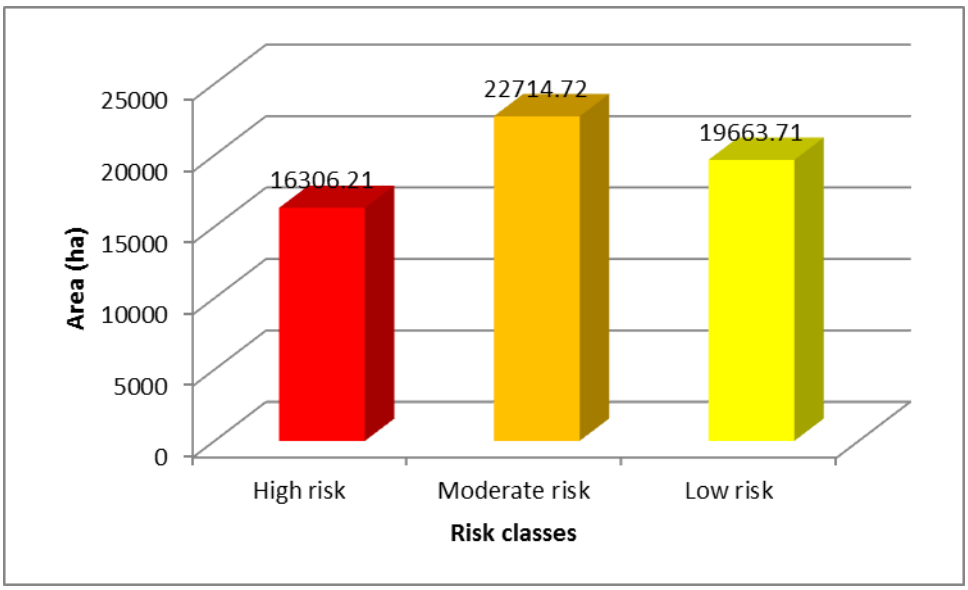


Figure 15. Distribution of fire risk classes (Kadisha)

Fire risk mapping Fireshed 2 (Rashaya)

Similarly a fire hazard map (**Figure 16**), a fire vulnerability map (**Figure 18**) and a fire risk map (**Figure 20**) were produced for Fireshed 2. Statistics on extent of the different classes associated with these maps, i.e., hazard (**Figure 17**) vulnerability (**Figure 19**) and risk (**Figure 21**), were also presented. More specifically it was observed that high hazard areas covered around 9% of the total area of the fireshed. High vulnerability areas covered 7% of the fireshed. Accordingly, high fire risk covered around 8% of the fireshed.

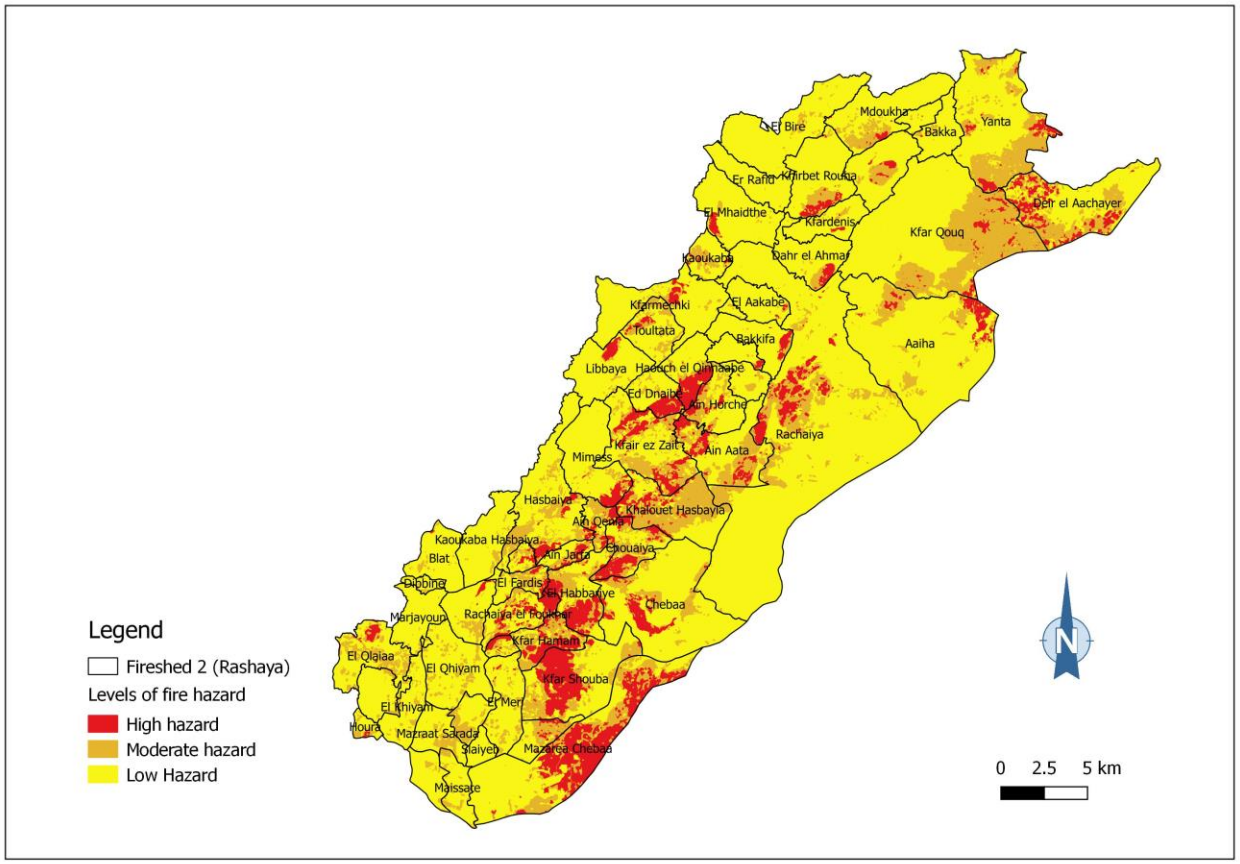


Figure 16. Fire hazard map of Fireshed 2 (Rashaya)

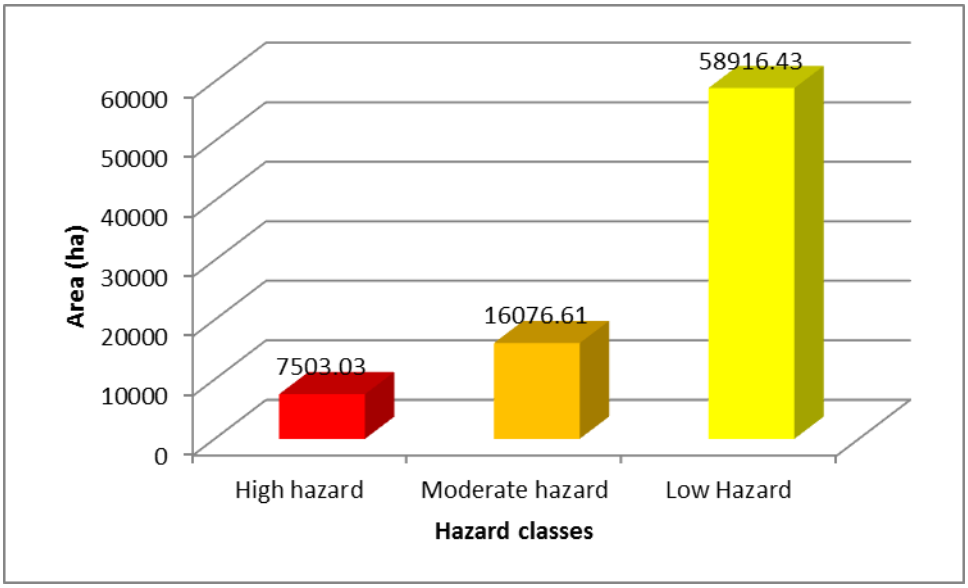


Figure 17. Distribution of hazard classes (Rashaya)

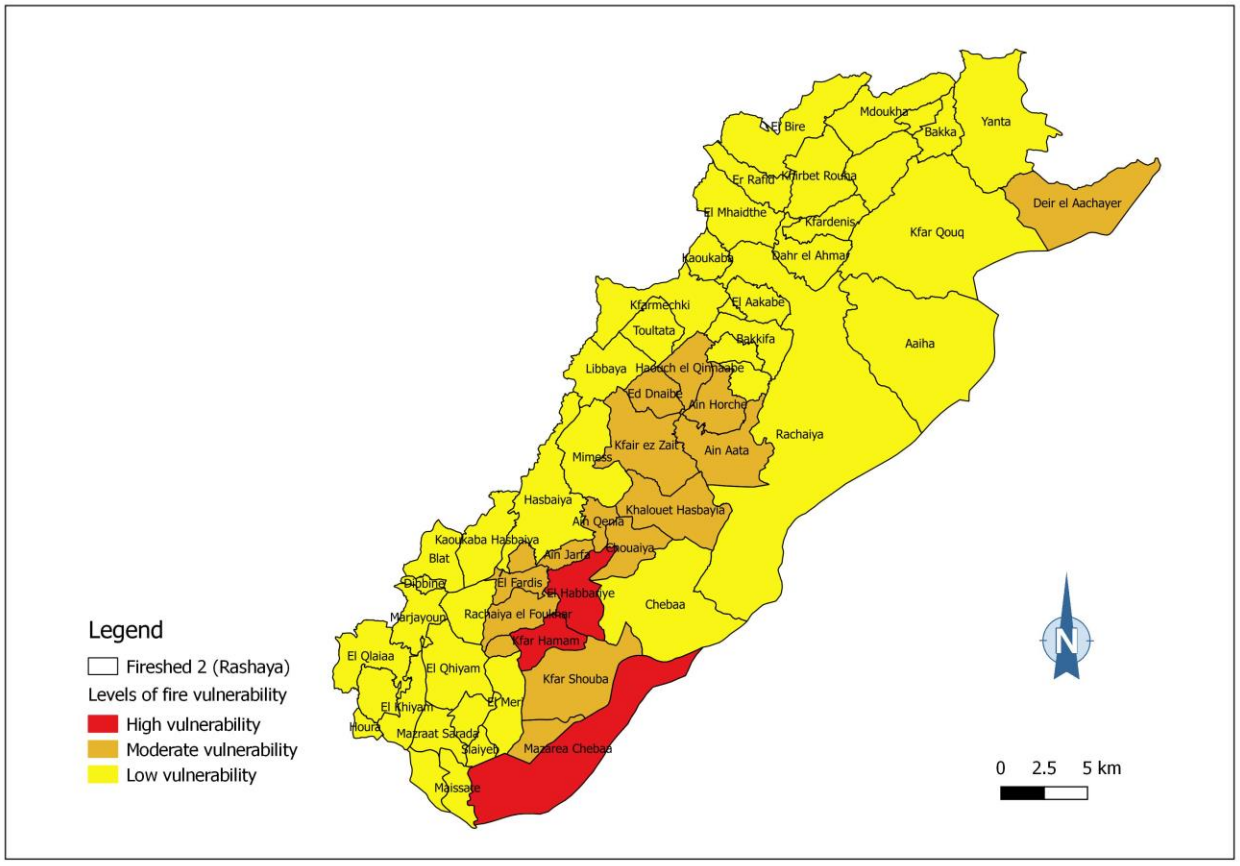


Figure 18. Fire vulnerability map (Rashaya)

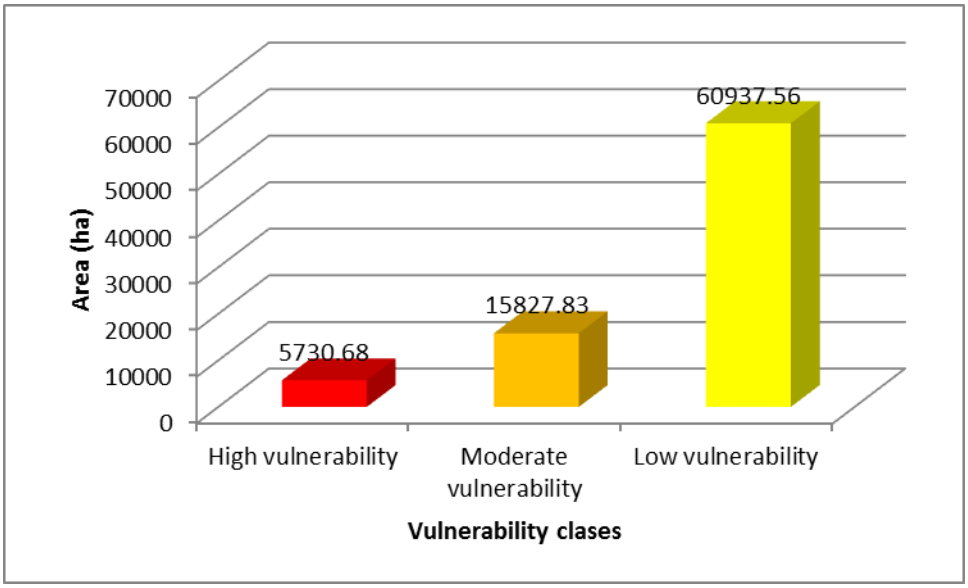


Figure 19. Distribution of vulnerability classes (Rashaya)

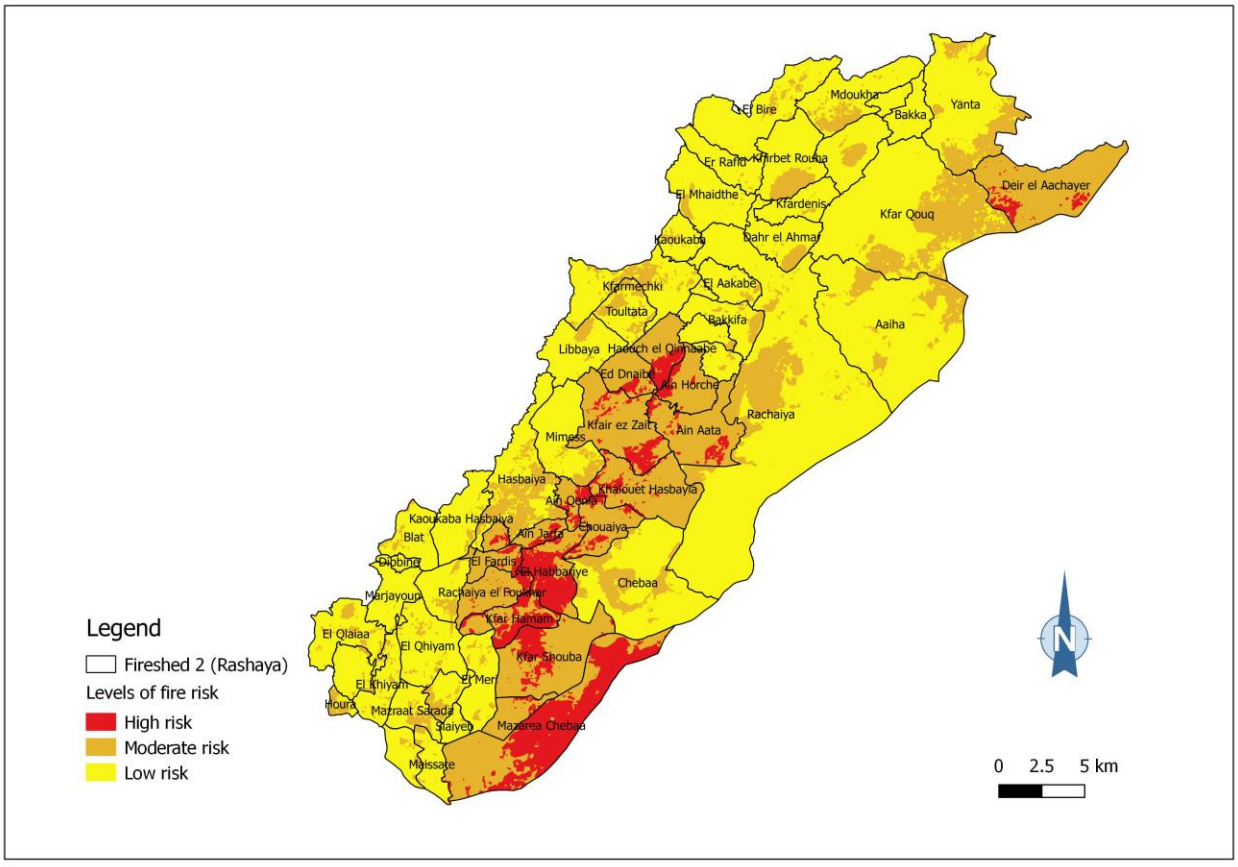


Figure 20. Fire risk map of Fireshed 2 (Rashaya)

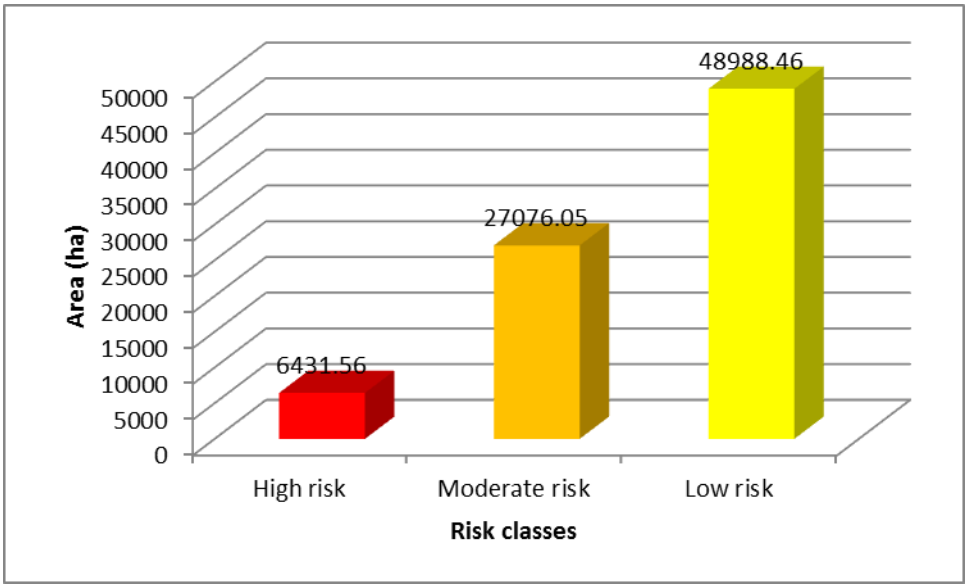


Figure 21. Distribution of fire risk classes (Rashaya)

Identification and characterization of priority sites

Identification of priority sites included first the calculation of the extent of high fire risk within each cadastral unit of a fireshed. Consequently, the relative extent of high fire risk within each village/town was presented on the maps.

Priority sites in Fireshed 1 (Kadisha)

A list of villages comprising high risk areas is presented below (**Table 4**). As a result, relative extent of high fire risk within each town/village was highlighted on the map (**Figure 22**

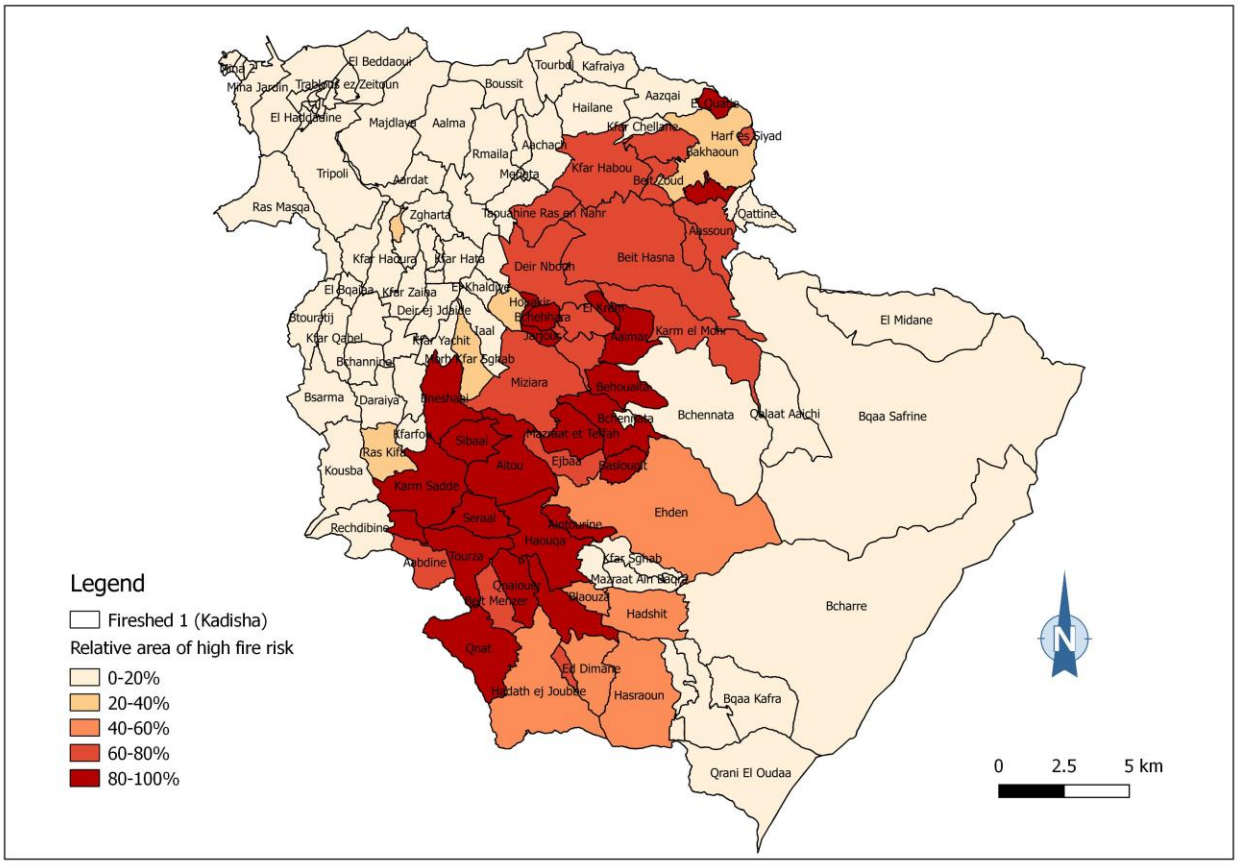


Figure 22).

Table 4. List of villages comprising high risk areas in Fireshed 1

Town	Area of high risk (ha)	Relative area of high risk

Town	Area of high risk (ha)	Relative area of high risk
Beit Hasna	1224.84	0.68
Bcharre	983.44	0.16
Ehden	978.9	0.41
Miziara	654.51	0.68
Karm Sadde	620.34	0.87
Karm el Mohr	607.24	0.86
Hadath ej Joubbe	586.76	0.51
Aitou	585.09	0.84
Hasraoun	565.42	0.56
Qnat	560.48	0.84
Haouqa	549.5	0.93
Deir Nbouh	520.62	0.74
Kfar Habou	481.1	0.64
Tourza	430	0.95
Wadi Qannoubine	400.76	1.00
Bneshaai	370.41	0.86
Toula	368.85	0.46
Bchennata	339.6	0.16
Hadshit	307.08	0.58
Mazraat et Teffah	293.04	0.93
Seraal	290.64	0.95
Behouaita	278.49	0.88
Aaimar	269.31	0.81
Aassoun	264.84	0.71
Qnaiouer	255.04	0.84
Sibaal	247.43	0.85
Ed Dimane	245.84	0.60
Mrah es Sraij	199.34	0.79
Aabdine	195.57	0.73
Bakhaoun	189.08	0.23
Taouahine Ras en Nahr	181.98	0.61
Beit Menzer	176.56	0.37
Ejbaa	166.08	0.63
Kaf el Malloul	160.82	0.75
Zghartaghrine	143.59	0.69
Baslouqit	137.47	0.86
Aintourine	129.14	0.85
El Kharroub	109.51	0.92
Bchehhara	99.2	0.89
Maghr el Ahoual	98.98	0.82
Beit Zoud	97.66	0.69
Ketrane	96.66	0.77

Town	Area of high risk (ha)	Relative area of high risk
El Quatie	85.13	0.90
Ras Kifa	83.69	0.28
El Krem	80.52	1.00
Morh Kfar Sghab	75.84	0.27
Jarjour	64.77	1.00
Rechdibine	63.89	0.15
Blaouza	61.65	0.44
Aazqai	59.44	0.14
Brissat	47.4	0.69
Sakhra	43.76	0.27
Kfar Haoura	36.11	0.12
Iaal	33.04	0.11
Houakir	32.31	0.96
Qattine	28.26	0.16
Harf es Siyad	24.57	0.73
Et Talle	13.47	0.29
Btermaz	2.07	0.92
Chira	1.73	0.72
Niha	1.19	0.94
Tannourine el Tahta	1.17	0.66
Billa	0.94	0.75
Tirane	0.69	0.59
Bnahrane	0.55	0.65
Dedde	0.55	0.25
Mazraat Bani Saab	0.52	0.57
Sir Ed Danniye	0.5	0.13
Bqarsouna	0.46	0.10
Sfainet el Qaitaa	0.31	0.26
Nimrine	0.15	0.19
Hraiqess	0.07	0.12
Kfour el Aarbe	0.07	0.19
El Hazmiye	0.06	0.25
Aadoui	0.04	0.03
Merkebta	0.03	0.05
Broj el Yahoudie	0.02	0.04
Ain Aakrine	0.01	0.01
Kfar Chellane	0.01	0.33

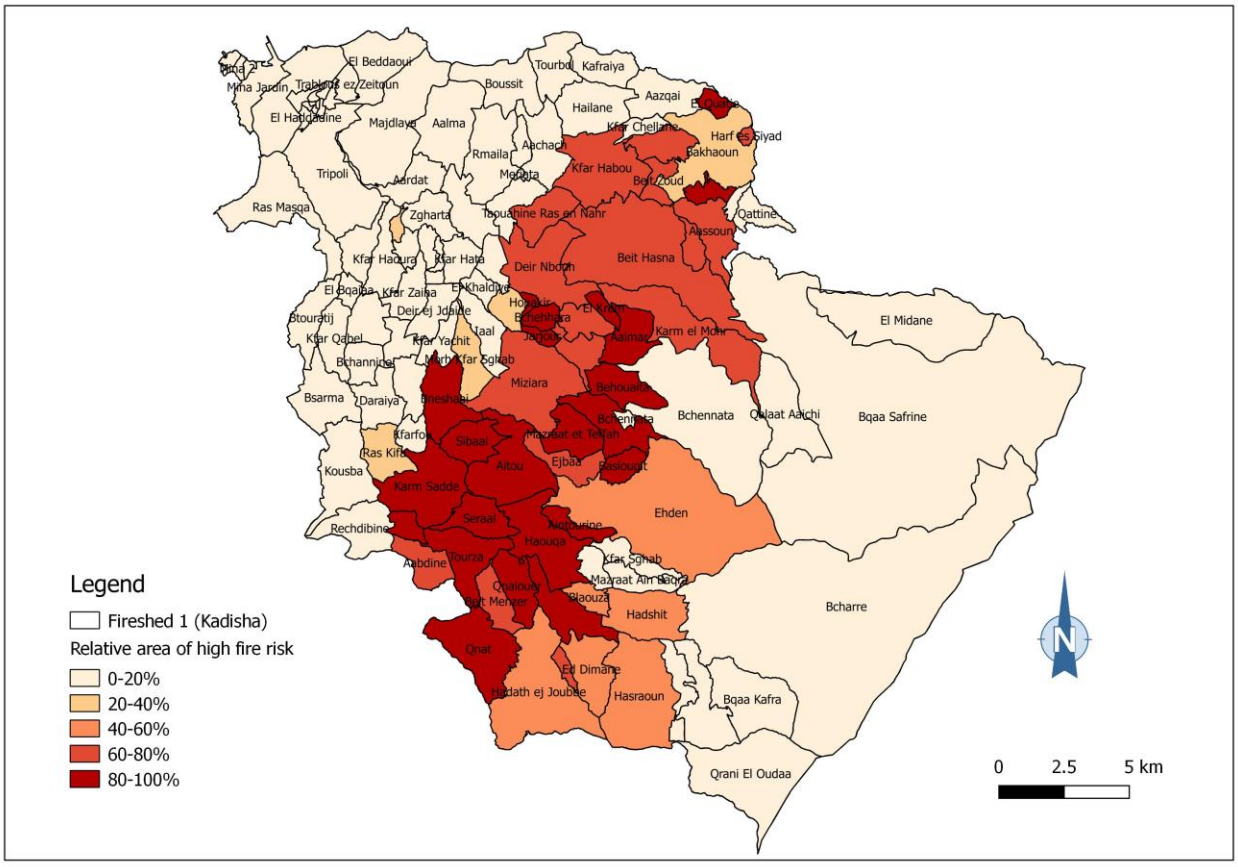


Figure 22. Relative area of high fire risk in Fireshed 1

Then, the Wildland-Urban Interface (WUI) was characterized within the study area by mapping first urbanized land **(Figure**

23

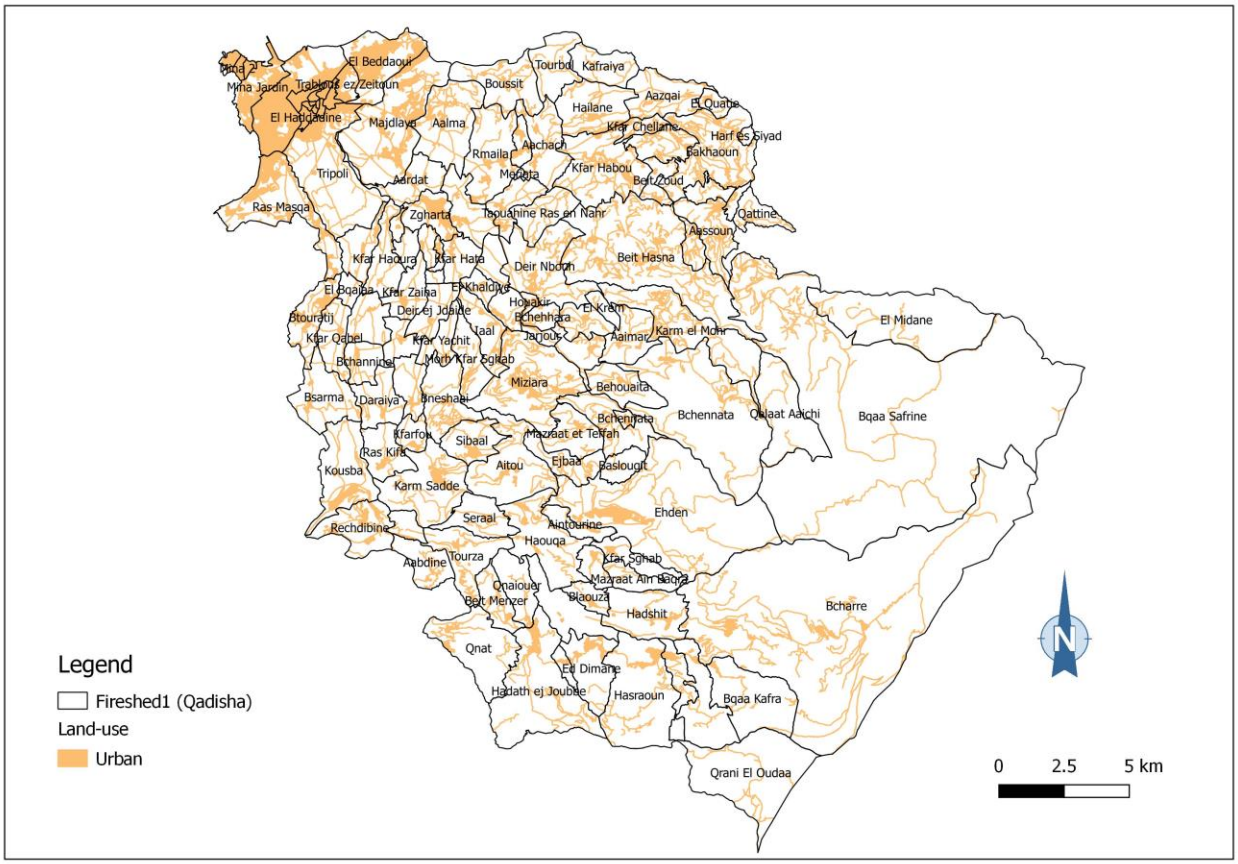


Figure 23). Many of these urbanized areas were intersected with fire risk areas, therefore increasing demographic vulnerability to fires.

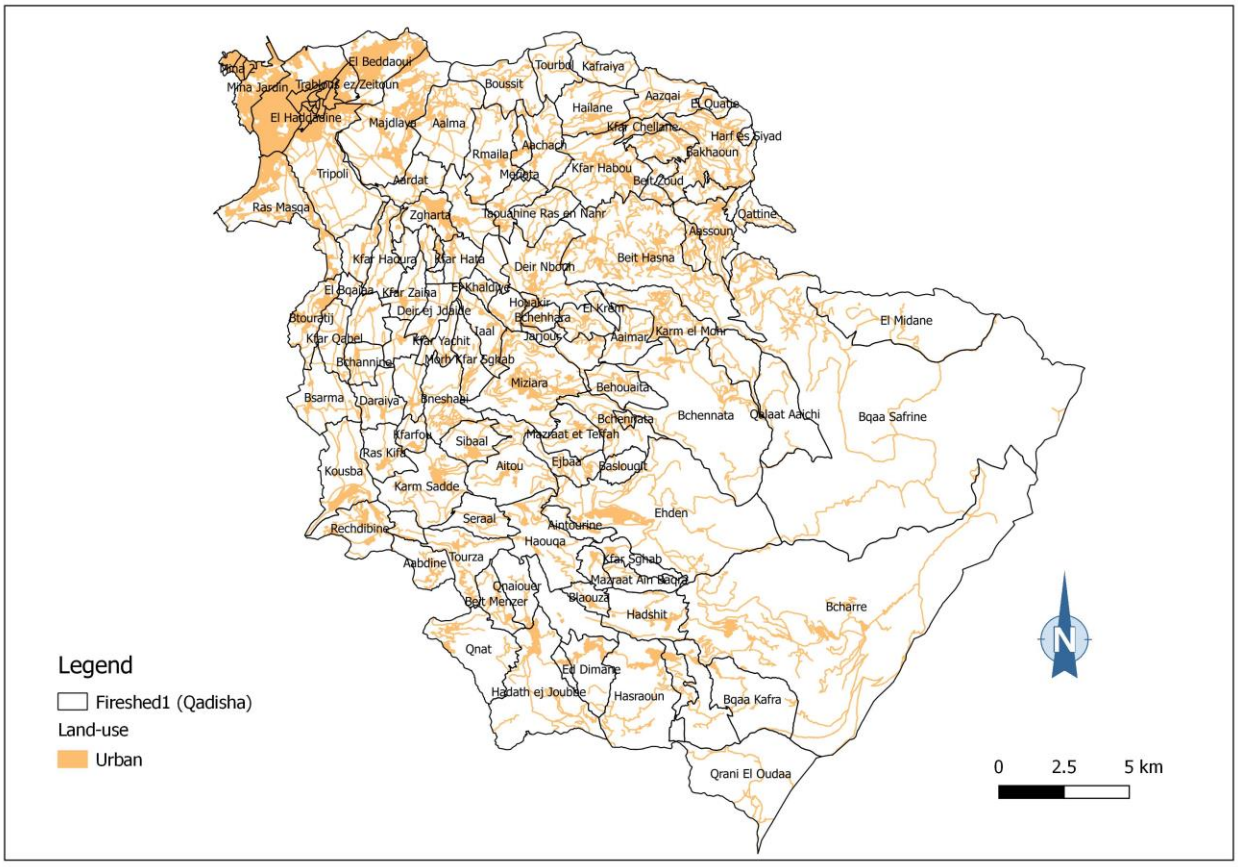


Figure 23. Urbanized areas within Fireshed 1

WUI is described here as the line, area, or zone where structures and other human developments meet or intermingle with undeveloped wildland or vegetative fuels. Lebanon's WUI is characterized by an increased wildfire danger (Mitri et al, 2014). Increased wildfire danger in the WUI is usually attributed to 1) wildfires posing a greater risk to people and infrastructure, 2) the necessity to protecting and evacuating people, thus reducing the possibility of resorting to means of direct firefighting, and 3) negligence of wildfire risk and carelessness, knowing that visitors and tourists are not usually conscious of the real danger of wildfires in the interface with urban areas (Mitri et al, 2014).

Some of the strategic constraints include 1) impossibility of using control burning as a firefighting tool, 2) constraints on heavy machinery and aircrafts, 3) difficulty of coordination between different firefighting bodies, and 4) compromised situation between the value to be

protected and the safety of the firefighters, among others. It is believed that the danger of large fire damage to human lives, private property, and natural resources is increasing (Mitri et al, 2014). As previously discussed, human activity patterns have changed the landscapes over the past three decades. In addition, there is insufficient or inadequate specific legislation for managing wildfire risk in the WUI.

Importantly, wildland areas surrounding urban centers and areas of scattered or isolated construction make fire protection increasingly difficult. In Lebanon, the increasing pattern of urban development into forested lands set up an additional threat of forest fires on human life and their economic well-being. Water provision in the WUI is not always available in good enough amounts to supply firefighting purposes. Also, it is difficult to access WUI areas, especially when firefighters need too much time to access houses in mid-slopes within wildland areas. It is important to highlight how houses and structures in Lebanon are generally poorly equipped with protection resources against wildfires (Mitri et al, 2014).

In this work, the assessment of wildfire risk in the WUI in Lebanon was based on mapping areas of high risk of fire within a buffer zone of 100 m from urbanized lands, settlements, and roads (**Figure 24**). The total area of the calculated WUI was 5,465 ha.

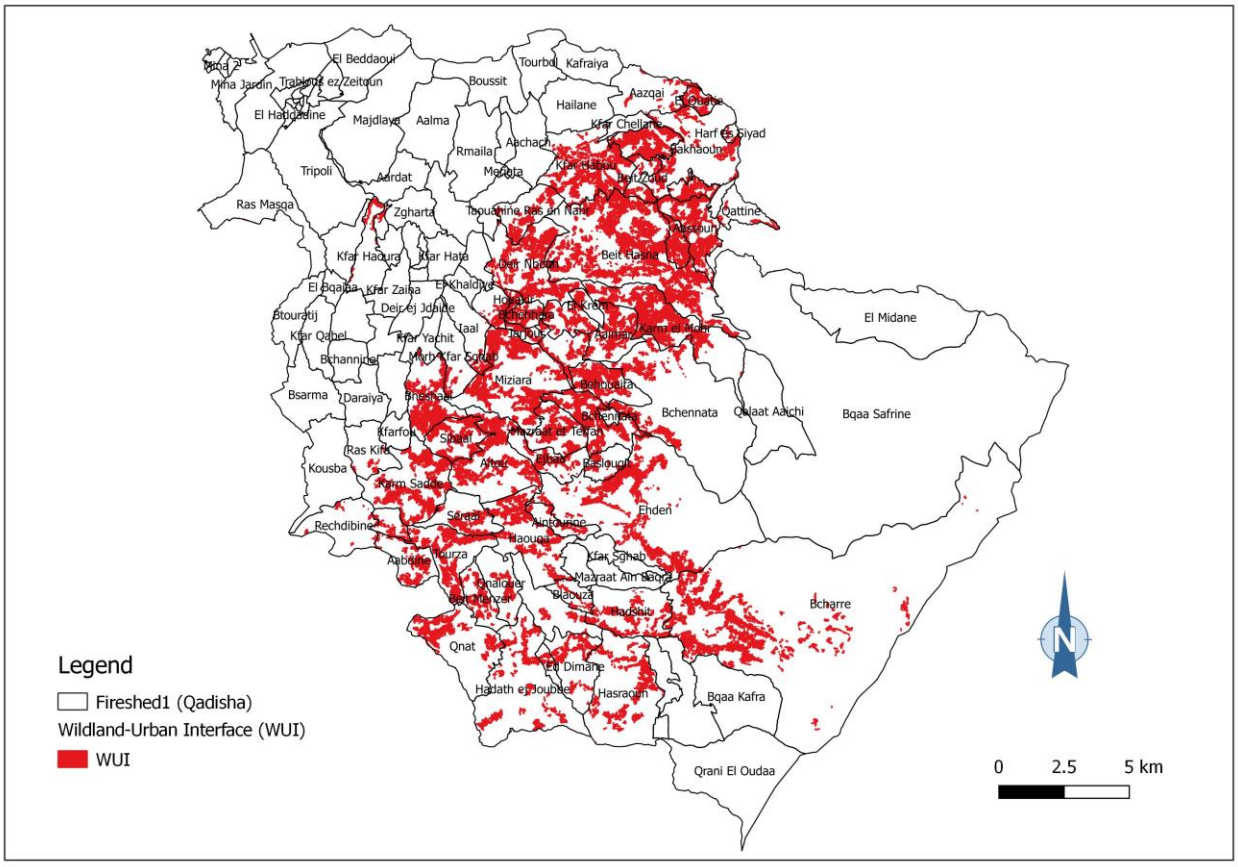


Figure 24. Wildland-Urban Interface in Fireshed 1

Then, the top villages (i.e., priority sites) including the largest extent of WUI of high risk can be extracted from

Table 5 and located on the map (**Figure 25**).

Table 5. Extent of Wildland-Urban Interface per village in Fireshed 1

Town	Area of WUI (ha)	Relative area of WUI
Beit Hasna	566.41	0.31
Bcharre	354.77	0.06
Karm el Mohr	275.26	0.16
Ehden	266.82	0.11
Miziara	265.7	0.28
Kfar Habou	220.15	0.29
Deir Nbouh	208.39	0.30
Aitou	189.35	0.27
Karm Sadde	181.77	0.26
Toula	160.04	0.20
Aassoun	157.18	0.42
Haouqa	148.23	0.11
Bneshaai	143.54	0.33
Tourza	133.11	0.29
Bchennata	124.98	0.08
Mrah es Sraij	119.71	0.47
Hasraoun	117.8	0.12
Behouaita	110.42	0.35
Aaimar	105.15	0.32
Qnat	101.59	0.15
Sibaal	98.01	0.34
Hadath ej Joubbe	95.93	0.08
Hadshit	94.81	0.18
Bakhaoun	90.81	0.11
Mazraat et Teffah	87.36	0.28
Ketrane	72.8	0.58
Taouahine Ras en Nahr	65.17	0.22
Zghartaghrine	62.25	0.30
Ed Dimane	58.12	0.14
Seraal	55.55	0.18
El Kharroub	52.87	0.44
Beit Menzer	51.96	0.11
Aabdine	50.79	0.19
Ejbaa	50.6	0.19
Kaf el Malloul	48.7	0.23
Bchehhara	45.61	0.41
Beit Zoud	43.32	0.31
El Quatie	42.67	0.45
Qnaiouer	28.06	0.09
Sakhra	27.82	0.17

Town	Area of WUI (ha)	Relative area of WUI
Aintourine	25.7	0.17
Aazqai	24.12	0.06
Baslouqit	21.33	0.13
Jarjour	21.02	0.32
Kfar Haoura	20.72	0.07
Maghr el Ahoual	19.76	0.16
Wadi Qannoubine	18.45	0.05
Iaal	18.13	0.06
Blaouza	17.19	0.12
Houakir	15.82	0.73
Morh Kfar Sghab	14.8	0.05
El Krem	14.45	0.18
Qattine	14.19	0.08
Brissat	11.89	0.17
Rechdibine	11.3	0.03
Ras Kifa	8.91	0.03
Harf es Siyad	5.39	0.16
Et Talle	4.51	0.10
Dedde	0.4	0.16
Bqarsouna	0.39	0.08
Sir Ed Danniye	0.26	0.05
Haql el Aazime	0.25	0.01
Mazraat Bani Saab	0.18	0.22
Sfainet el Qaitaa	0.17	0.14
Btermaz	0.16	0.14
Bnahrane	0.11	0.18
Kfar Chellane	0.1	0.01
Tannourine el Tahta	0.1	0.09
Bqaa Safrine	0.09	0.01
Chira	0.09	0.04
Nimrine	0.09	0.15
Bazaoun	0.08	0.01
Bqorqacha	0.08	0.01
Kfarfou	0.08	0.01
Tirane	0.08	0.07
Kfar Yachit	0.07	0.01
Bkeftine	0.06	0.01
El Hazmiye	0.06	0.25
Hariq Zgharta	0.06	0.01
Kousba	0.06	0.01
Zgharta	0.06	0.01
Bane	0.05	0.01

Town	Area of WUI (ha)	Relative area of WUI
Billa	0.05	0.02
Aadoui	0.03	0.02
Bqaa Kafra	0.03	0.01
Aachach	0.02	0.01
Aarjess	0.02	0.01
Hraiqess	0.02	0.05
Kfar Sghab	0.02	0.01
Rachaaine	0.02	0.01
Ras Masqa	0.02	0.01
Ain Aakrine	0.01	0.01

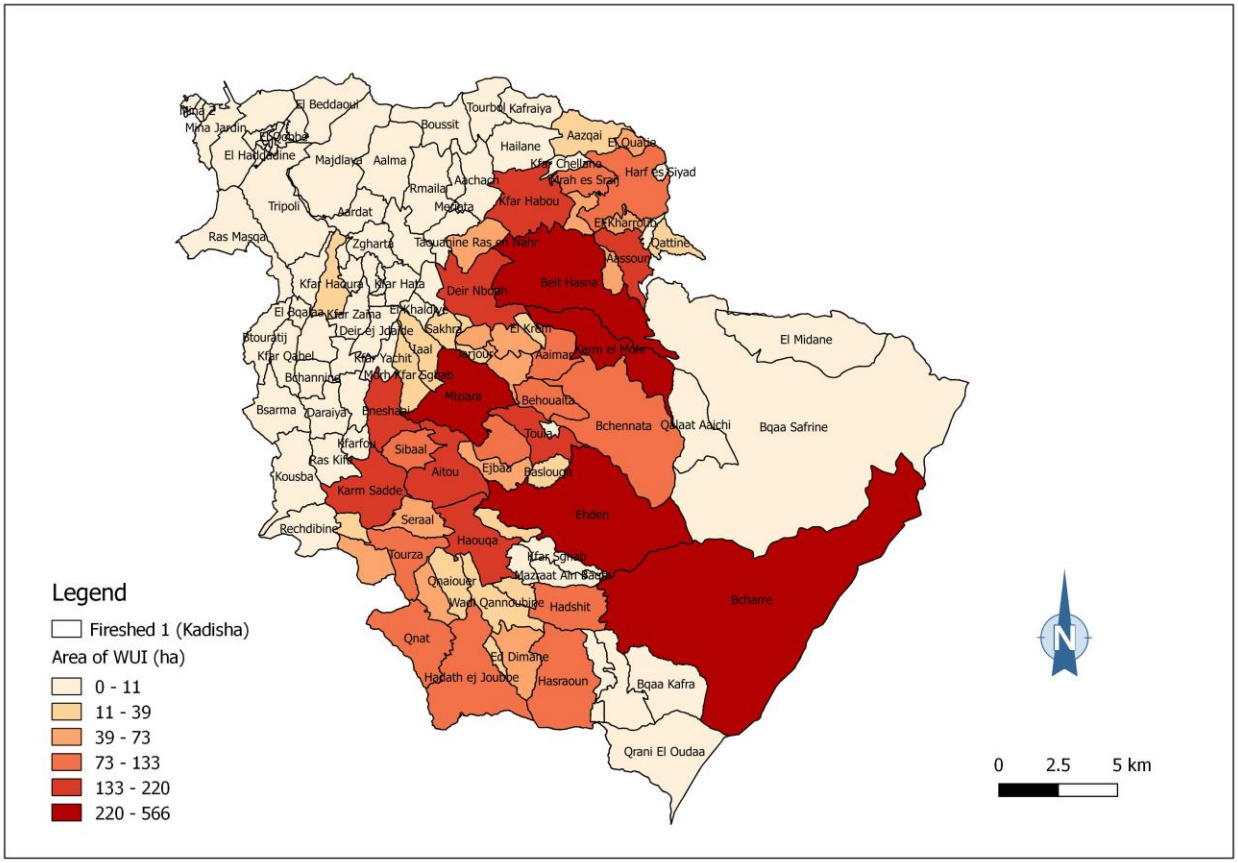


Figure 25. Priority sites within Fireshed 1 in function of the extent of WUI per village

Priority sites in Fireshed 2 (Rashaya)

Similarly, a list of villages comprising high risk areas in Fireshed 2 is presented below (**Table 6**). As a result, relative extent of high fire risk within each town/village was highlighted on the map (**Figure 26**).

Table 6. List of villages comprising high risk areas in Fireshed 2

Town	Area of high risk (ha)	Relative area of high risk
Mazarea Chebaa	2088.44	0.54
El Habbariye	773.25	0.67
Kfar Shouba	560.12	0.25
Kfar Hamam	494.39	0.68
Kfair ez Zait	387.79	0.21
Khalouet Hasbayia	314.3	0.18
Deir el Aachayer	263.38	0.11
Chouaiya	248.17	0.29
Rachaiya el Foukhar	227.06	0.28
Ain Aata	222.27	0.14
Haouch el Qinnaabe	216.33	0.29
Ed Dnaibe	130.3	0.60
Ain Horche	116.13	0.13
Ain Qenia	89.87	0.24
Ain Jarfa	75.88	0.24
El Majidiye	73.65	0.14
El Fardis	61.17	0.14
Khreibet Hasbaiya	43.32	0.24
Abou Qamha	40.82	0.19
Arnoun	0.44	0.23
Haloua	0.35	0.20
Mazraat Deir el Aachayer	0.26	0.03
Mazraet-El-Jrein	0.25	0.03
Chbail	0.1	0.05
Mazraat Doumiat	0.02	0.04
Zellaya	0.01	0.02

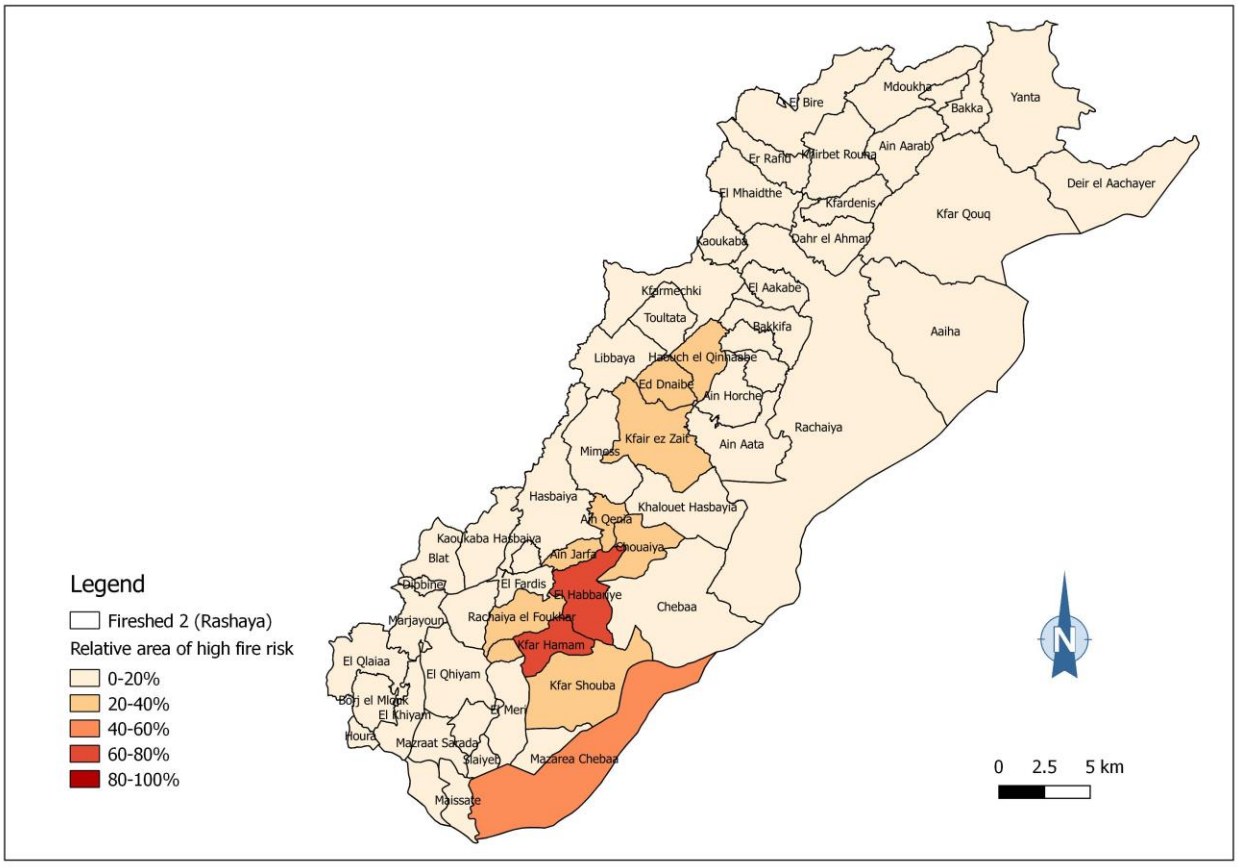


Figure 26. Relative area of high fire risk in Fireshed 2

Then, the WUI was characterized within the fireshed by mapping first urbanized land (**Figure 27**). Many of urbanized areas were intersected with fire risk areas, therefore increasing demographic vulnerability to fires.

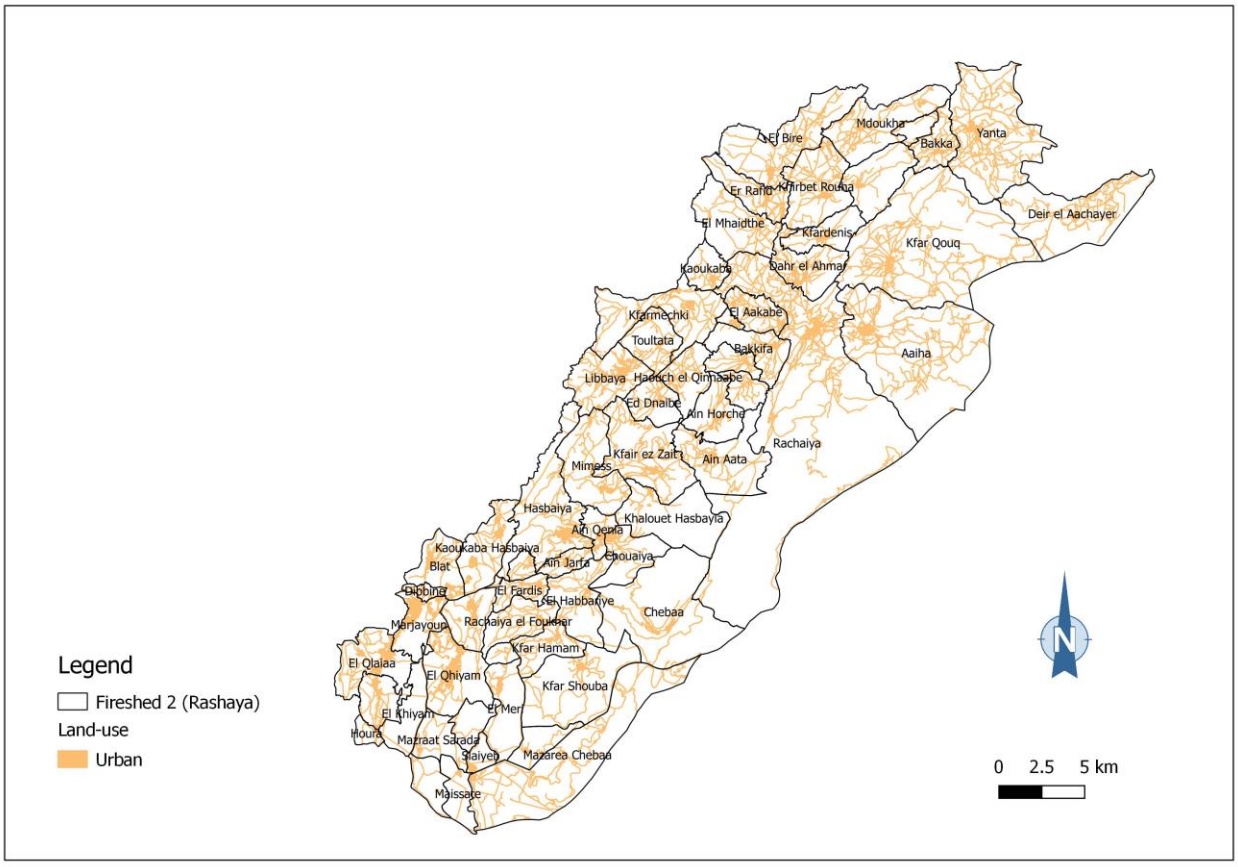


Figure 27. Urbanized areas within Fireshed 2

Similarly, the assessment of wildfire risk in the WUI in Lebanon was based on mapping areas of high risk of fire within a buffer zone of 100 m from urbanized lands, settlements, and roads (**Figure 28**). The total area of the calculated WUI was 400 ha (**Table 7**).

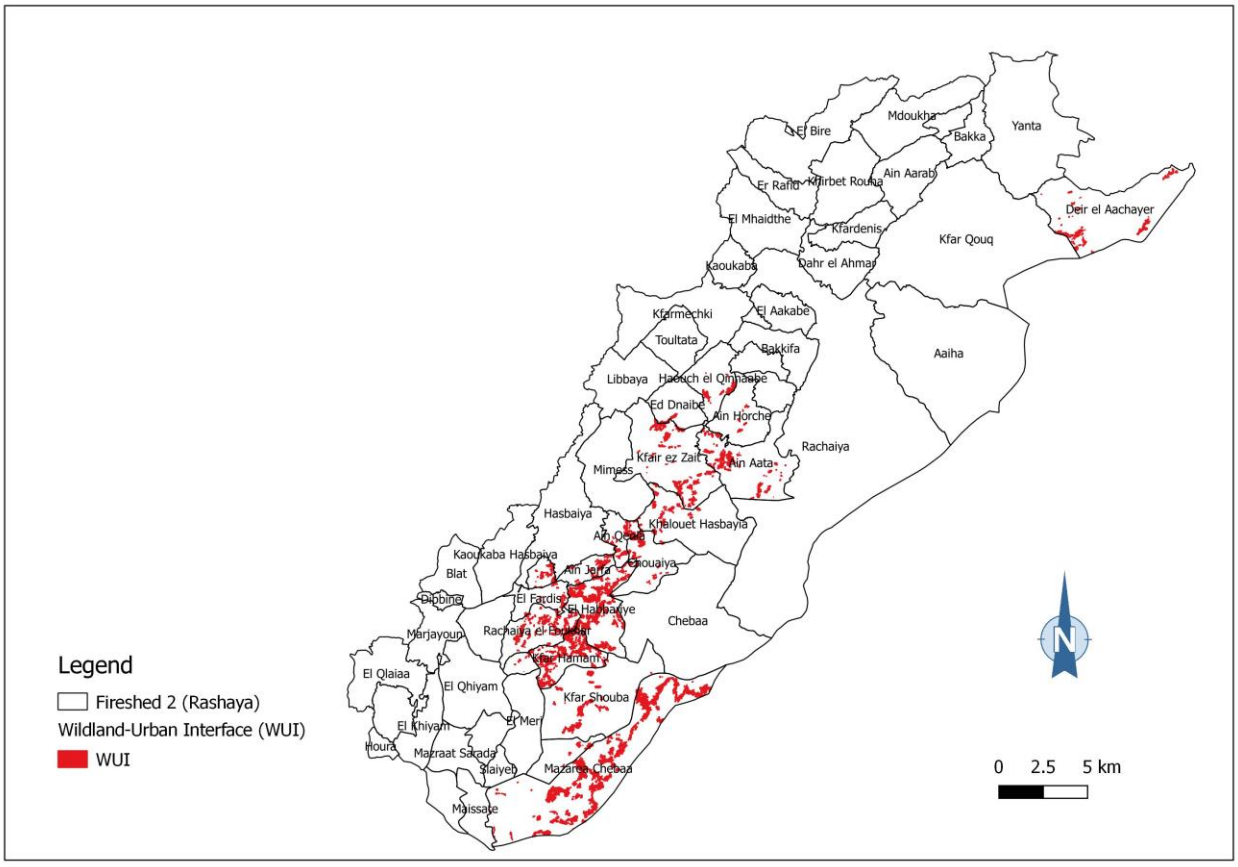


Figure 28. Wildland-Urban Interface in Fireshed 2

Then, the top villages (i.e., priority sites) including the largest extent of WUI of high fire risk are represented in **Table 7** and located on the map (**Figure 29**).

Table 7. Extent of Wildland-Urban Interface per village in Fireshed 2

Town	Area of WUI (ha)	Relative area of WUI
Mazarea Chebaa	400.2	0.17
El Habbariye	198.29	0.17
Kfar Hamam	157.12	0.22
Rachaiya el Foukhar	83.5	0.10
Kfair ez Zait	83.01	0.04
Ain Aata	73.93	0.05
Kfar Shouba	56.93	0.03
Deir el Aachayer	51.52	0.02
Khalouet Hasbayia	41.35	0.02
Ain Qenia	38.98	0.11
Ain Jarfa	33.29	0.10

Town	Area of WUI (ha)	Relative area of WUI
Chouaiya	33.29	0.04
Abou Qamha	22.42	0.11
Haouch el Qinnaabe	21.94	0.03
El Fardis	15.83	0.04
Ed Dnaibe	10.22	0.01
El Majidiye	8.74	0.02
Ain Horche	5.93	0.01
Khreibet Hasbaiya	4.03	0.02
Hasbaiya	0.15	0.00
Chbail	0.08	0.03
Haloua	0.08	0.02
Kfar Qouq	0.06	0.01
Mimess	0.06	0.01
Arnoun	0.05	0.02
Chebaa	0.04	0.01
El Meri	0.04	0.01
Mazraat Deir el Aachayer	0.02	0.01
Mazraet-El-Jrein	0.02	0.01
Maissate	0.01	0.01
Mazraat Doumiat	0.01	0.02
Zellaya	0.01	0.02

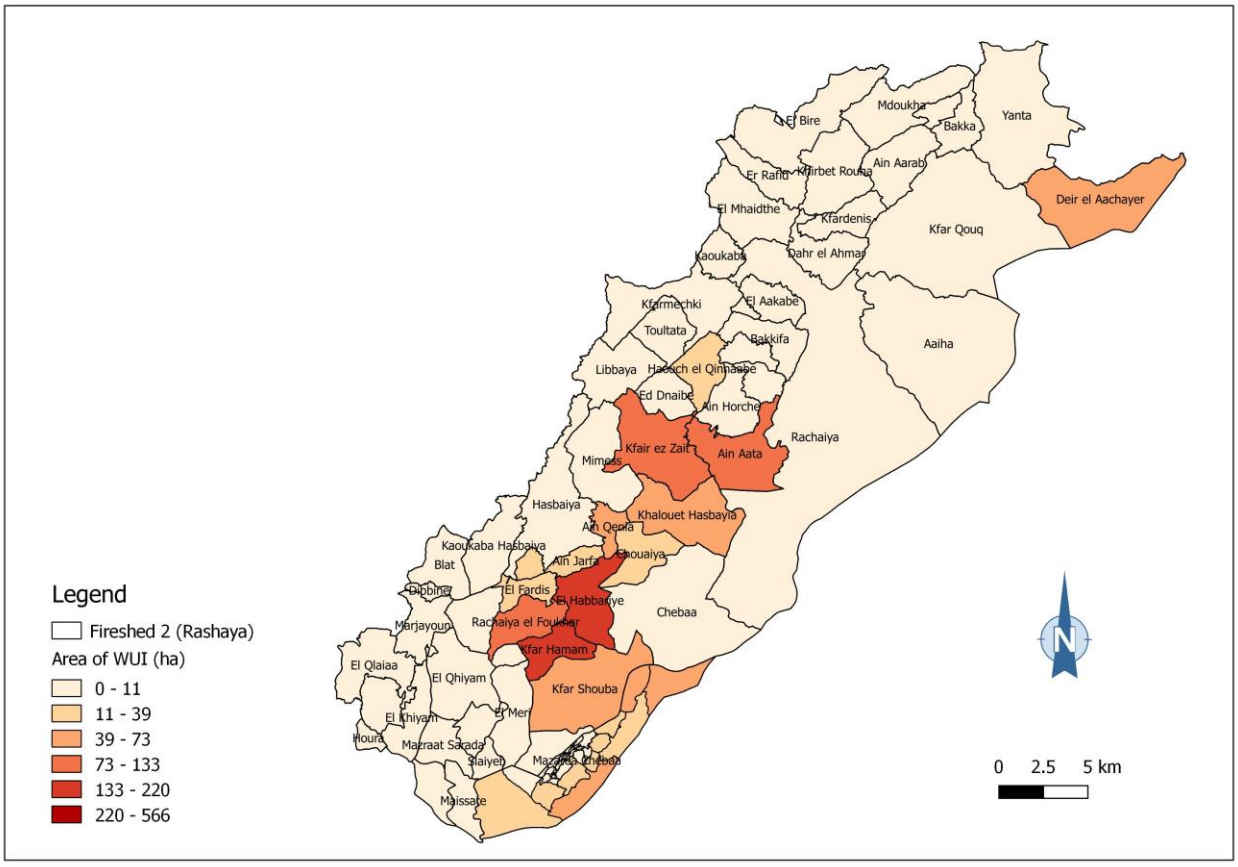


Figure 29. Priority sites within Fireshed 2 in function of the extent of WUI per village

Preliminary recommendations

General recommendations

In general, best practice guidelines for 1) managing fire risk in Lebanon's abandoned agricultural lands, 2) managing fire risk in Lebanon's dense forests, and 3) engaging communities in developing plans for wildfire risk management activities were produced and published by IOE-UOE/LRI (2014) in both Arabic and English. It is recommended that community groups within the fireshed area especially those in high risk areas and their surrounding refer to such guidelines for future activities in relation to fire risk management. In reference to LRI (2017), the general recommendations are presented in **Annex 1**.

The results in this study have interesting implications for fire prevention and land management. In line with the provisions of Lebanon's National strategy for forest fire management (MOE/AFDC, 2009), assessing fire risk as a product of hazard and vulnerability and mapping of WUI contribute to make the inhabitants becoming aware of fire risk especially in WUIs.

The following specific recommendations are initially presented for use in the roundtable discussions within each fireshed to help in guiding and building future actions plans.

Specific recommendation in relation to Fireshed 1

The WUI map in Fireshed 1 presents key information to identify locations where vegetation has to be managed and reduced in order to reduce fire risk and protect better houses and their inhabitants in case of wildfire. More specifically, a careful behavior is essential to avoid fire ignition especially in the villages of Beit Hasna, Bsharre, Karm El Mohr, Miziara, Kfar Habou, and Deir Nbouh among others. This will locally decrease the risk of fire either by reducing fire propagation (i.e., through biomass removal) and/or by reducing fire ignition probability.

Protected areas within the fireshed (e.g., Ehden nature reserve, cedar forests, Ouadi Qannoubine, etc.) require special consideration in the planning for fire management actions. In addition, plans, guidelines

and operational procedures should be developed with a view to reduce fire risk and damaging impacts of fire in protected forests.

One concern of increased fire risk is the presence of dense forests. Methods of fuel treatment in dense forests are essentially required for fire risk reduction, debris removal following pruning in forests, and use of biomass (UNDP/UOB, 2015). Such dense forests include:

- Dense oak forest (3,150 ha) mostly located in Miziara, Ouadi Qannoubine, Ehden Haouqa, Toula, Hadshit, Kahf El Malloul, Behouiata, Hasroun, Hadath El Joubbeh, and Beit Hasan (i.e., above 100 ha in each).
- Dense pine forest (902 ha) mostly located in Mazraat et Toufah, Aitou, Ejbaa, Tourza, Miziara, Toula, Aabdine, Bneshai, Qnat (i.e., above 40 ha in each).
- Dense mixed forest (723 ha) mostly located in Kahf el Mohr, Deir Nbouh, Beit Hasna, El krem, Zghartaghrine, Bakhaoun, Aimar (i.e., above 40 ha in each).

Strategic actions for fuel management in these dense forests include but are not limited to:

- Develop a fuel reduction programme that considers the potential uses of debris and vegetation and, where appropriate, encourage local communities to use wood for fuel and perhaps grasses and shrubs for grazing or other community needs.
- Undertake fuel treatment activities to facilitate effective fire suppression and protection of communities and resources.

Another major environmental concern is the fire risk associated with abandoned land amounting to a total of 430 ha and located mainly in Bsharre, Bqaa Kafra, Aitou, Ejbaa, Hadath El Joubbe, Ehden, Aimar, Haouqa, Bqaa Sifrine, Brissat, and Hasroun (i.e., above 20 ha in each). Most of biomass (i.e., highly flammable vegetation) growing on these lands require special attention in terms of fire safety.

Specific recommendations in relation to Fireshed 2

Similarly, the WUI map in Fireshed 2 presents key information to identify locations where vegetation has to be managed in order to protect better houses and their inhabitants in case of wildfire. More specifically, a careful behaviour is essentially needed to avoid fire ignition especially in the villages of Mazarea Chebaa, El Habbariey, Kfra Hamam, Rashaya el Foukhar, Kfair ez Zait and Ain Ata among others.

This will also locally decrease the risk of fire either by reducing fire propagation (i.e., through biomass removal and/or by reducing fire ignition probability).

As in Fireshed 1, one concern of increased fire risk is the presence of dense forests. Methods of fuel treatment in dense forests are essentially required for fire risk reduction, debris removal following pruning in forests. Such dense forests include:

- Dense oak forest (i.e., 329 ha) mostly located in Hasbaya, Kfair ez Zait, El Habbariyeh, Rashaya El Foukhar, Ain Jarfa, and Abou Qamha among others (i.e., above 30 ha in each).
- Dense pine forest (i.e., 118 ha) mostly located in Ebl es Saqi, Kfar Hamam, Ain Horshe, Khreibet Hasbaya and Mimess mong others (i.e., above 8 ha in each).
- Dense mixed forest (i.e., 78 ha) mostly located in Mimess, Ain Qenia, Khalwet Hasbaya and Chouiya (i.e., above 10 ha each).

Again, strategic actions for fuel management in these dense forests include but are not limited to:

- Develop a fuel reduction programme that considers the potential uses of debris and vegetation and, where appropriate, encourage local communities to use wood for fuel and perhaps grasses and shrubs for grazing or other community needs.
- Undertake fuel treatment activities to facilitate effective fire suppression and protection of communities and resources.
- Manage rangelands with the support of ongoing activities (i.e., the sustainable land management in the Qaraoun catchment project- SLMQ).

The other major environmental concern is the fire risk associated with abandoned land amounting to a total of 295 ha and located mainly in Chebaa, Yanta, Toultata, Khalwet Hasbaya, Mimess, LIbbaya, Deir el Aachayer and Rashaya (i.e., above 10 ha in each). Most of biomass (i.e., highly flammable vegetation) growing on these lands requires special attention in terms of fire safety. The SLMQ project provides different opportunities for land restoration and fire risk reduction in light of a previously conducted study for land degradation assessment in the region.

References

LRI (2017). Fire risk assessment at the fireshed level of Naher El Kelb (report). Lebanon Reforestation Initiative, Beirut.

Mitri, G., Jazi, M., Antoun, E., and McWethy, D. (2014). Managing wildfire risk in Lebanon. University of Balamand. Kelhat, El Koura, Lebanon.

MOE/AFDC (2009). Lebanon's National Strategy for Forest Fire Management (Decision No. 52 – 2009), Mitri, G. (Editor), Beirut.

UNDP/UOB (2015). Lebanon's National Blueprint for a Sustainable Forest Biomass: promoting renewable energy and forest stewardship (Mitri, G. Editor). UNDP-CEDRO, Beirut. Pp. 118.

Glossary of terms

Firewise: The National Fire Protection Association (NFPA's) Firewise USA program teaches people how to adapt to living with wildfire and encourages neighbors to work together and take action now to prevent losses.

Fire Adapted Communities: The National Wildfire Coordinating Group defines a fire adapted community as “A human community consisting of informed and prepared citizens collaboratively planning and taking action to safely coexist with wildland fire”.

Fire risk: The term ‘‘fire risk’’ considers the probability of a fire occurring and spreading (i.e., fire hazard) and includes values and expected losses (i.e., vulnerability).

Fire hazard: A fuel complex, defined by volume, type, condition, arrangement, and location that determines the degree of ease of ignition and the resistance to control.

Fire vulnerability: Fire vulnerability expresses the potential damage from wildfires and it may be defined as: “The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging impacts of a hazard”

Wildland-Urban Interface (WUI) The WUI is described as the line, area, or zone where structures and other human developments meet or intermingle with undeveloped wildland or vegetative fuels.

Annex 1. General recommendations

There is an urgent need to protect communities especially in high risk areas by mitigation activities in the wildland-urban interface. This comprises the use of land management tools that fit the landscape. Such tools include strategic thinning, fuels modification through chipping, and managed wood utilization where appropriate. To do so, it is recommended to have interactive fire maps by using spatial data and information produced within the framework of this work. These interactive maps should be made available to be viewed by local stakeholders.

Simultaneously, fire adapted communities need to be promoted. This includes mitigating fuels, evacuation planning and drills, awareness, and education. To learn more about fire adapted communities the following reference www.fireadaptednm.org provides insights within the following objectives:

- home-owners build the concept of defensible space into their decisions,
- communities integrate wildland fire into land-use planning and infrastructure decisions,
- civic institutions collaborate to be prepared for wildfire,
- architects, planners, landscapers, and developers integrate realities of fire risk into their work flow, and
- Communities support land managers in their efforts to restore fire-adapted ecosystems.

In this work, recommendations for 1) research, information and analysis, 2) fire risk modification, and 3) readiness for improved fire risk management are provided. These come in line with the existing strategic components of Lebanon's National Strategy for forest fire management.

In research, information and analysis:

- Benefit from the results of this current assessment (e.g., review, maps, priority sites, etc.) for use in promoting the improvement, know-how sharing, monitoring and dissemination of knowledge on fire management.
- Take advantage of existing monitoring and reporting systems (e.g., annual fire reports published by the University of Balamand and Ministry of Environment), Firelab web application (ioe-firelab.balamand.edu.lb), and national reports (those produced for the UNFCCC, UNCCD, and CBD) and undertake further research work.

- Consult existing fire danger forecast systems for assessment of fire danger within the fireshed (these include the Firelab system of the University of Balamand and the fire bulletin of the General Directorate of Civil Defense).
- Develop objectively verifiable indicators at the fireshed level to evaluate the performance of local fire risk management initiatives.
- Archive and report data and information about fires at the fireshed level.
- Display warning signs about the risk of fires. Warning signs are mounted and displayed in areas easily accessible by visitors and hikers among others.
- Map and display water sources and accessibility across the forest. Accordingly, water outlets should be clearly shown on relevant maps including the road and trail networks for use by firefighters in case of a fire event. Maps will be at the disposal of municipalities.

In risk modification:

- Consider higher involvement of municipalities at all levels in forest management and involve religious authorities when possible.
- Adopt the produced fire risk mapping results for developing and implementing fire prevention measures (e.g., fire and fuel breaks).
- Identify opportunities and needs to allow land owners/users especially in high risk areas adopt fire resilient land uses (i.e., sustainable forest management practices).
- Develop and explore opportunities to adopt fire resilient land uses (these include economic incentives, innovative management systems, etc.)
- Promote traditional farming practices, controlled grazing, and sustainable fuel wood gathering and charcoal production especially in high risk areas.
- Avoid burning crop residues during fire seasons by providing alternatives to farmers (e.g., biomass shredding and briquetting).
- Develop preventive silviculture and fuel management activities aiming at reducing fire hazard (e.g., pruning and thinning) and minimizing impact on communities especially in the wildland-urban interface (e.g. vulnerable communities).
- Treat vegetation near houses, picnic area, and monasteries/churches at risk of being affected of fire and to reduce the risk of fire propagation from these points.

- Clear vegetation under high voltage lines and using red balloons on the electric wires to alert helicopters.
- Raise awareness at the population levels and involve individuals from communities of high risk areas to whom awareness raising and surveillance campaigns are addressed.
- Take full advantage of existing legal provisions by giving special consideration to regulations in connection with punishments, restriction of fire ignition, and clearing vegetation around houses and infrastructure.
- Adopt specific fire safety codes (i.e., set of rules or definitions) especially in the identified wildland-urban interface in line with current policies and regulations
- Adopt specific fire safety standards (determined here as good practices) especially in the identified wildland-urban interface.

In readiness:

- Activate the role of municipalities located within high risk areas to increase readiness.
- Undertake all possible provisions by individuals, communities and fire and land management agencies to be prepared before a fire event occurs, and improve interventions and safety in monitoring the probability of fire and detecting the event of fire.
- Consult fire danger forecast bulletins provided by Firelab (ioe-firelab.balamand.edu.lb) and the civil Defense for improving readiness.
- Conduct a proper distribution at the landscape level of fire-fighting infrastructures and conduct an inventory of current fire-fighting resources which are available and desired future resources (ground infrastructure) such as fire lookout towers, water reservoirs, forest tracks and road network in general, forest strips with low tree density and low shrub cover, fire break areas of first and second level, forest tracks with fire break lines along them, protection perimeters in urbanized areas and fire-fighting units.
- Promote cooperative local surveillance programs including neighborhood watch programs and patrols in high risk areas during severe fire weather conditions.
- Set up a mechanism to educate and target the various land users groups about how to respond to a fire.