

1445 Blue-Green Factor (BGF) mapping in QGIS

NINA Report

User Guide and Documentation

Peter Horvath
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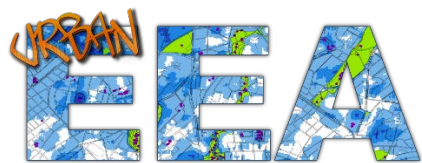
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Abstract

Horvath, P., Barton, D.N., Hauglin, E.A. & Ellefsen, H.W. 2017. Blue-Green Factor (BGF) mapping in QGIS. User Guide and Documentation - NINA Report 1445 [s.46]

The blue-green factor (BGF) is a rapid assessment tool to help quantify minimum municipal requirements for surface water management, vegetation qualities and biodiversity in outdoor areas of property developments. BGF-QGIS makes it possible to calculate the blue-green factor for larger areas than in the original Excel-based methodology, by taking advantage of remote sensing data, GIS datasets, and CAD-based design proposals. It also provides a flexible platform for adjusting the scoring of blue-green qualities to suit specific local conditions and priorities.

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Sammendrag

Horvath, P., Barton, D.N., Hauglin, E.A. & Ellefsen, H.W. 2017. Blue-Green Factor (BGF) mapping in QGIS. User Guide and Documentation - NINA Report 1445 [s.46]

Blågrønn faktor (BGF) er et verktøy som kvantifiserer krav til uterom når det gjelder vannhåndtering, vegetasjon og biodiversitet i byggesaksprosjekter. BGF-QGIS gjør det mulig å beregne BGF for flere eiendommer og større arealer enn i den opprinnelige Excel-baserte metoden, ved å ta i bruk digitale kartleggingsverktøy som integrerer fjernmålingsdata, GIS dataset og CAD-basert design. QGIS plattformen gjør det også mulig for enkelt-kommuner å tilpasse BGF metoden til lokale forhold ved å endre kriterier og vektorer.

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Foreword

The BGF-QGIS application was made possible thanks to the original Blue-green factor methodology developed in 2014¹ by PBE- Oslo Kommune, Bærum Kommune, Dronninga Landskap, COWI and C.F. Møller, with the support of the Cities of the Future Project, funded by the Norwegian Ministry of Local Government and Modernisation.

The clear and easily implementable BGF method (2014) using Excel spreadsheets was the basis for the later development of an Android app called “BG Calculator”. The authors of this Documentation gratefully acknowledge the origins of the methodology and the support from different NINA coordinated projects to develop the BGF tool further. The Android App development was supported by the EU FP7 project OpenNESS (2012-2016). Programming of the BGF-QGIS application by Peter Horvath was funded by the ENABLE project, supported by the Biodiversa programme at the Norwegian Research Council. A BGF-QGIS beta version was tested and improved with support of the URBAN EEA project, funded by the Miljøforsk programme of the Norwegian Research Council.

We are grateful to Yuan Wang, University of Helsinki, and students at the Oslo School of Architecture and Design (AHO) course “By og Arkitektur” Autumn 2017, for testing the BGF-QGIS and suggesting improvements.

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Oslo, December 2017

¹ Framtidens Byer, Blågrønn faktor. Veileder byggesak. Hoveddelen 28.01.2014. 2014, Plan og bygningsetaten, Bærum Kommune, Dronninga Landskap, COWI, C.F. Møller.

1 Introduction

1.1 What is BGF?

Blue-green factor (BGF) is a tool to assess an urban property development's surface water management and vegetation qualities. It uses classification of blue-green areas and additional qualities to calculate a total BGF factor per property area. It was developed by the Project Future Cities (Figure 1) and explained in a 2014 Guidance Manual for building permits (Figure 1).

1.2 Approaches to calculating BGF

The 2014 BGF Guidance Manual uses a spreadsheet calculator in MS Excel to determine the total blue-green factor of a property area. The user identifies the area for blue and green surfaces, and blue and green 'additional qualities'. The BGF score is calculated as an area-weighted sum surfaces and additional qualities (Figure 2). The Excel spreadsheet (Figure 3) required areas to be calculated beforehand (i.e. in the field or from a planning map). In addition, the calculations were limited to one property per spreadsheet and no graphical/map output was available. The practical implementation was thus limited.

The OSLOpenNESS project developed an Android application – BGF calculator² - to make the BGF accessible to a wider public on Smartphones. The BGF calculator utilized both the calculator and integrated a spatial representation of blue-green structures using satellite images in Google Maps. The total property BGF could be automatically calculated by mapping the blue-green structures within the property using the satellite image. The Android BGF Calculator App also had limitations. It was only available on Android, with minimal customization. Surface areas could be digitised using a stylus on a pad, but was inaccurate when using ones fingertip. The App could not utilize property cadastre boundaries to delineate individual properties. Furthermore, the App only stored BGF projects on the Smartphone's internal memory with no import or export functions to a database. The BGF Calculator App only contains a simple export function of a csv file of the data via e-mail.



Figure 1. Blue-green factor Guidance Manual for building permits, developed by the Future Cities Project. Source: Framtidens Byer, Blågrønn faktor. Veileder byggesak. Hoveddelen 28.01.2014. 2014, Plan og bygningsetaten, Bærum Kommune, Dronninga Landskap, COWI, C.F. Møller.

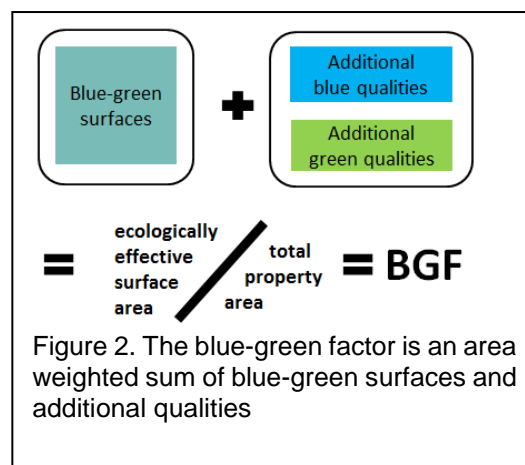


Figure 2. The blue-green factor is an area weighted sum of blue-green surfaces and additional qualities

² The BGF Calculator App for Android is available here: https://play.google.com/store/apps/details?id=no.nina.bgf_app&hl=en

Blue Green Factor (BGF) 29.05.2013 Developed for Bærum og Oslo municipalities by Dronninga landskap, COWI and CF Møller					
Value	Symbol	Factor	Description	ARE	BGI
		Plot Area (including the built area) Fill out the area			0
1.BLUEGREEN AREAS					
1		Open permanent water surface that can receive rainwater	Permanent water surface supplied rainwater from the site, regardless of whether this is a channel with concrete bottom stream with green banks or other type of water surface. Only the water surface is considered	0	0
0.3		Partially permeable surface like gravel, crushed stone, and reinforced grass surface	Hard surfaces with permeability, providing infiltration. For example, grassy areas reinforced with concrete, gravel or crushed stone. Not surfaces of underlying hard covers if the soil depth is less than 80 cm.	0	0
0.2		Impermeable surfaces with drainage to vegetated areas or an open drainage magazine	Eg. concrete, asphalt, roofs and paving stones. Calculated for the area corresponding to the size of the vegetation surface that accepts water. The drainage magazine must have the capacity according to municipal requirements for discharges to official sewer system (ie it holds about 20 to 30 l / m² runoff area)	0	0
0.1		Impermeable surfaces with drainage to a local closed storm water drainage	Eg. concrete, asphalt, roof surfaces with runoff led to a closed facility for retention and purification of the water. This also applies to underground solutions combined with irrigation of trees. The whole area counts assuming drainage magazine is according to municipal requirements for discharges to off. sewer system (ie it holds about 20 to 30 l / m² runoff area).	0	0
1		Surfaces with vegetation associated with soil or bedrock	Vegetation growing in soil and has contact with the soil below. Beneficial for the development of flora and fauna and storm water can be pulled down to ground water. The point also applies to natural rock outcrops and cliffs.	0	0
0.8		Surfaces with vegetation, not associated with soil > 80 cm	Vegetation growing in soil on minimum 80 cm depth, but not in contact with the earth / ground below, eg. on top of a garage or roof. The depth is great enough that larger trees can grow.	0	0
0.6		Surfaces with vegetation, not associated with soil 40 - 80 cm	As above, but with 40-80 cm ear so that hedges, large bushes and small or medium trees can grow.	0	0
0.4		Surfaces with vegetation, not associated with soil 20 - 40 cm	As above, but with 20-40 cm earth for that perennials and small bushes can grow.	0	0
0.2		Surfaces with vegetation, not associated with soil 5 - 20 cm	As above, but with 5 - 20 cm earth that is enough for grasses, herbaceous plants and other ground cover can grow.	0	0
2. Additional qualities = Blue and Green additional qualities that give extra points. The same area can therefore be counted a number of times below					
Blue additional qualities					
0.3		Natural edges to water surfaces	Water surfaces that are counted above, can also be counted in this category there is access for flora / fauna at ground level to a natural substrate and edge (riparian) zone. Eg: stream, canal and pond with green edges The area to be considered is the width of the water surface.	0	0
0.3		Rain bed or equivalent	Vegetation area that serves as rain bed or similar planted infiltration that collects, diffuses and infiltrates rainwater into the soil / ground. This does not apply to permanent water surfaces and diffusion basin counted in blue surfaces above.	0	0
Green additional qualities, Points below (trees) should be filled in as a number					Number
1		Existing large trees > 10 m	Existing large trees; over 10 m. factor is 25 m²/tree .	0	0
0.8		Existing trees that can be expected to grow to over > 10 m	Existing trees that can be over 10 m tall. Forest trees, hardwood deciduous trees and park trees, eg. elm, ash, birch, oak, linden, maple, chestnut, pine and many more. It is expected that the tree should have enough soil to grow (min 100 cm). Factor: 25 m²/tree (x 0.8).	0	0
0.6		Existing trees that can be expected to grow to be small to medium, 5 - 10 m	Existing trees that are 5-10 m tall. Ornamental trees and fruit trees, e.g., apples cherry, magnolia, pear, locust and many more. Also applies to pruned trees. It is expected that the tree should have enough soil to grow (min 60 cm). Factor: 16 m²/tree (x 0.6).	0	0
0.7		Newly planted trees that are expected to be > 10 m	Trees that will be over 10 m high. Species: see the field listed above. It is expected that the tree will have enough soil to grow (min. 100 cm). Factor: 25 m²/tree (x 0.7).	0	0
0.5		Newly planted trees that are expected to be 5 - 10 m	Trees which will become 5-10 m high. Species: see the field above. It is expected that the tree will have enough soil to grow (min 60 cm). Factor: 16 m²/tree (x 0.5).	0	0
Points below should be filled in as m2					Area m2
0.6		Native vegetation	Establishing or protection of surfaces with a large content of valuable plant species that are a part of the local, historical natural and cultural landscape.	0	0
0.4		Hedges, bushes and multi-stemmed trees	Hedges, bushes and multi-stemmed trees with a height over 3 m. Calculated for a maximal area corresponding to the drip zone of (crown of the tree) m²/tree.	0	0
0.4		Green walls	For climbing plants and other green walls, the factor is calculated for the wall area that can be expected to be covered over the course of 5 years (a maximum of 10 m height for climbing plants).	0	0
0.3		Perennials and other ground cover	Does not apply to lawn grasses	0	0
0.1		Contiguous green areas over 75 m2	Contiguous green area that is larger than 75 m², as for example large grassy lawns, planted areas, or others.	0	0
Points below are filled in with the number 0,05					0.05
0.05		Connection to existing blue-green structure.	If the blue and / or green elements in the area can be connected to the existing structure outside the area in question. The connection should be obvious. For example, a stream opening, a link to the existing channel or water surface, drainage, the extension of an alley or a grove, merging of several courtyards with free movement between them. This provides a general increase of 0.05 in BGF.	0	0
TOTAL BLUEGREEN FACTOR (BGF)					###

Figure 3. Facimile of the MS Excel calculator in the original BGF methodology (Fremtidens Byer 2014) (original in Norwegian)

The above mentioned limitations led to development of an integrated scheme interface in QGIS to calculate BGF. QGIS is an open-source Geographic Information Software (GIS) for viewing, editing, and analysis of geospatial data.

The motivation was to improve and include the following processes:

- Ability to use BGF process directly in the field (in addition to office use)
- Utilize multiple ortho-photos and/or satellite images (e.g. to switch between summer and winter images – to map both the canopy and understorey vegetation)
- Use additional GIS land cover layers to support further appraisals such as ecosystem services
- Use additional spatial structures (such as property boundaries) and data (e.g. for snapping or as aggregation units...) to aid the mapping process.
- Possibility to adjust weighting of BG structures in the future
- Producing map outputs of different property areas or scenarios
- Customizing interface

By using the Free and Open Source Software QGIS, one can accomplish all of these goals within a highly customizable and user-friendly interface.

1.3 Using BGF-QGIS in urban planning

The original BGF methodology was intended as a tool to support the integration of blue and green structures in building and landscape architectural design at property level. It opened up the possibility of municipalities providing recommendations or requirements for a minimum BGF scores that should be achieved within the delimited area of single properties. BGF guidance (2014) proposed that minimum BGF scores be differentiated according to the density of inner and outer city areas.

However, the evaluation of minimum requirements for BGF scores at the level of neighbourhoods, encompassing several properties with different forms of program, ownership and landscape characteristics was not easy to evaluate using the original BGF methodology. By enabling BGF in a QGIS platform, it is possible to cost-effectively map existing blue-green structures by means of integrating remote sensing data, GIS datasets, and CAD-based design proposals.

BGF-QGIS thus makes it possible to evaluate alternative planning and design scenarios using BGF methods for larger areas. This should make the BGF mapping and valuation methodology an assessment tool that is useful also in planning and urban development processes. Furthermore, the BGF-QGIS methodology applied within urban planning and development provides an efficient quantitative measurement tool. It makes quantification of blue-green surfaces and qualities equally available as other forms of quantitative planning and design data. BGF in a QGIS platform not only enables data collection in larger areas than before, but also accentuates and visualizes environmental amenities that have often been undervalued in urban planning processes.

One size does not fit all. In this QGIS application, users can adapt the BGF methodology to include new blue-green structures, as well as change the relative importance of each structure in the total BGF score. This makes it easier to adapt the methodology to particular needs and conditions of different municipalities.

1.4 BGF method modifications implemented in BGF-QGIS

During the development of BGF Calculator App we recognised that ‘trees’ in the original BGF method required an adaptation for stands of trees where it is impractical to count individual trees. We implemented an option where tree crown cover could be mapped, while keeping the original option of entering the individual number of trees on a property. In the original BGF methodology, individual trees are assumed to have standard canopy area depending on their height classification. BGF users had to have knowledge of tree height in order to implement this function.

In BGF-QGIS we have simplified the idea of tree canopy mapping further. The user now maps the tree canopy area of individual trees, as well tree stands, in the same way, by digitising canopy cover. While tracing canopy sizes for individual trees is moderately more time consuming than entering a number for different tree sizes on the property, canopy mapping provides an accurate estimate of tree canopy. This mapping can be validated against ortho-photos. Considering the structural importance of trees for ecosystem functions this is a feature that responds to the purpose of the original BGF methodology, as well meeting future needs for detailed mapping of urban ecosystem qualities.

2 Set up and getting started

2.1 Get the basic overview of GIS

Before beginning with BGF-QGIS, it is highly recommended to get briefly familiarized with the basic knowledge about GIS, for example by going through the following easy step-by-step introduction tutorials:

- GIS systems (http://docs.qgis.org/2.14/en/docs/gentle_gis_introduction/index.html)
- QGIS software and interface (http://docs.qgis.org/2.14/en/docs/training_manual/index.html)

2.2 Required QGIS version & plugins

This project was built under version of QGIS 2.18.11 'Las Palmas' that was released on 21.07.2017. It is recommended to use the latest available version of QGIS software (but NOT older than mentioned above).

To obtain your version of QGIS, follow the link below:

<https://www.qgis.org/en/site/forusers/download>

All the required project files that will be used in this tutorial are available for download at GitHub <https://github.com/peterhor/BGF-QGIS>

2.3 Installation Workflow

Please follow this workflow in order to avoid structural problems within BGF-QGIS

- 1) Install QGIS
- 2) Install required plugins
- 3) Download folder structure from GitHub
- 3) Open project and start Mapping

2.4 Required Plugins

In order for the BGF-QGIS project to work correctly, you need to have specific plugins installed in QGIS. Please install all plugins BEFORE opening the BGF project in QGIS.

- **Form value relation**
 - Form value relation plugin implements of complex dynamic filters and makes available multi-level relations and dependencies between the drop-down items in the fill-in forms.
 - <https://www.itopen.it/a-new-qgis-plugin-allows-dynamic-filtering-of-values-in-forms/>
- **refFunctions**
 - refFunctions utilizes a more flexible Field calculator functions in QGIS and allows to control behaviour between different layers
 - <https://geogear.wordpress.com/2014/11/13/reffunctions-v1-0/>

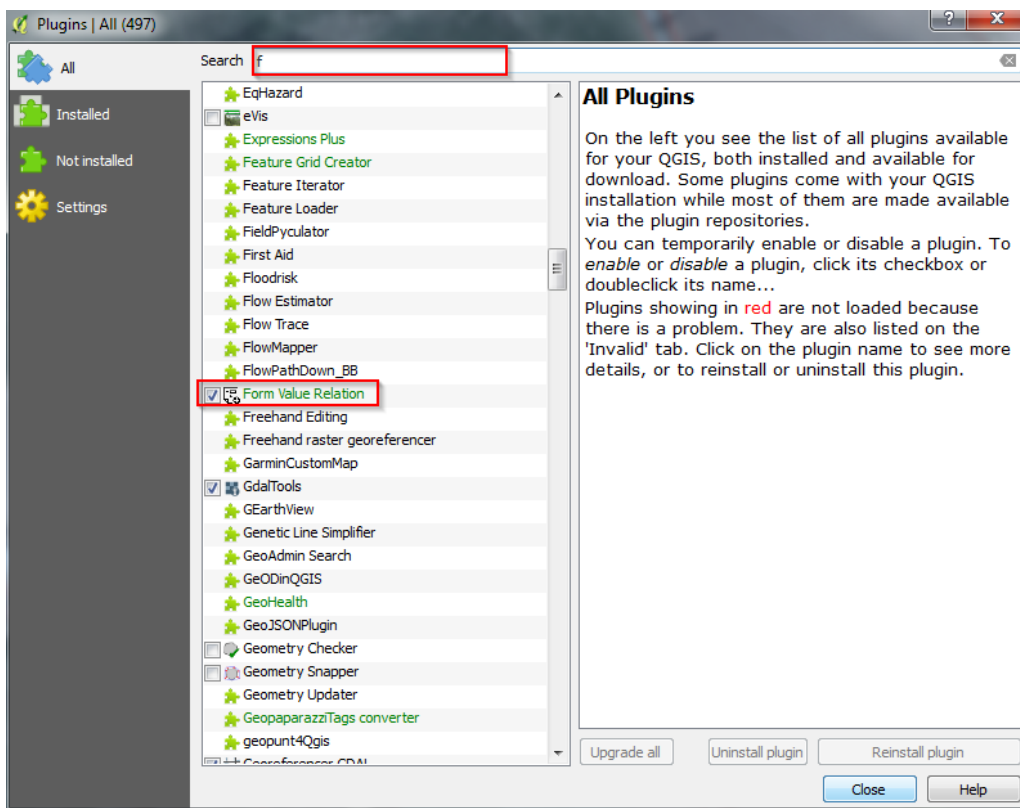
2.5 Optional Plugins

- **QGIS Cloud Plugin**
 - Qgis Cloud Plugin is a powerful Web-GIS platform for publishing maps, data and services on the internet.
 - <http://qgiscloud.com/>
- Other options for publishing include qgis2web, QGISQUICK, Lizmap

2.6 Installing Plugins

Installing plugins is available through the following menu:
 Plugin -> Manage and Install Plugins... ->

Choose the abovementioned plugins and hit “install plugin” .



Continue by installing all three required plugins: “Form value relation”, “refFunctions”, and “Qgis Cloud Plugin”.

IMPORTANT! Open BGF-QGIS project only after all three plugins are installed. If not the added functionality will not be available in the project.

2.7 Opening a BGF-QGIS project

You can open the QGIS project file “BGF_qgis_project.qgs” directly from your file browser. Alternatively you can navigate to the project file “BGF_qgis_project.qgs” through an already opened instance of QGIS:

Project -> Open (Ctrl+O)

The project is now directly prepared for you to start mapping (skip to section 4 Digitizing BGF Structures). However, if you want to customize or add additional Web Map Services or Raster/Vector layers, start by following the sections below: 3.1 How to add WMS and 3.2 Adding raster / vector files from disk.

A backup copy (preferably zipped) should be kept in case you need to recover your project or start over.

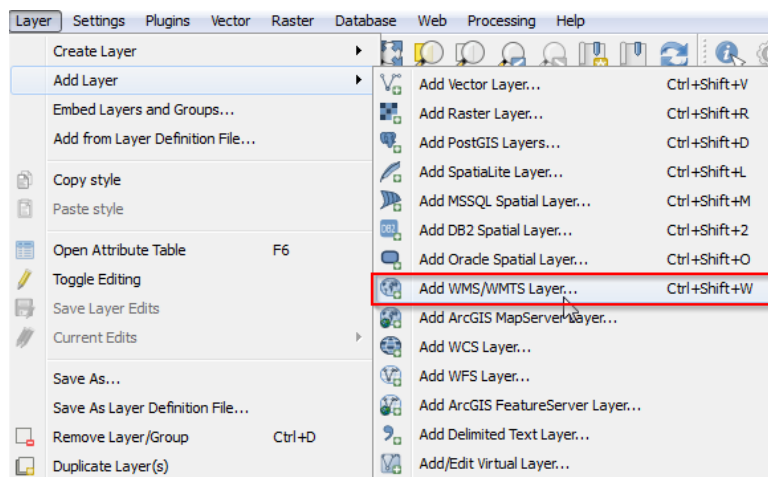
2.8 Adding additional background data

A Web Map Service (WMS) is a standard protocol for serving georeferenced map (over the Internet) images which a map server generates using data from a GIS database.

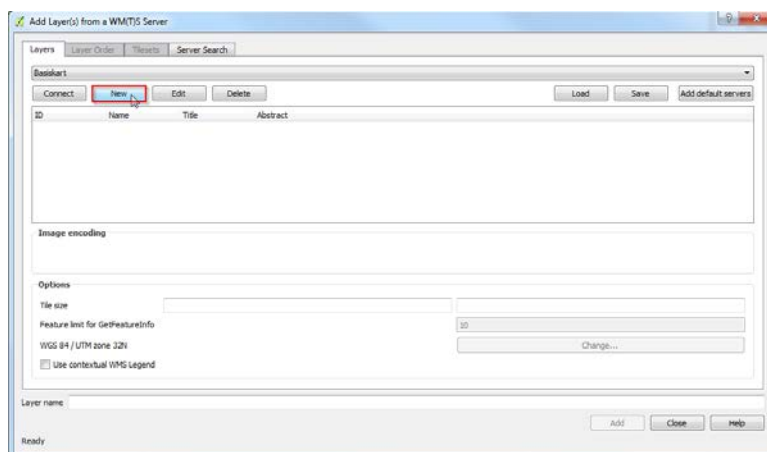
Since it is streamed over internet, it does not take up space in your final project, such as raster/vector data would. However, the disadvantage it has over raster/vector files stored locally is that its structures are not editable/trackable within the project other than visually. Also you have to be ONLINE and with a good internet connection for accessing WMS. Otherwise rendering WMS can be slow and make mapping less efficient. This can be an obstacle in the field.

This is an **OPTIONAL** step for those who want to have additional maps from the WMS. You can add WMS layer from different servers by using their URL link. Do this by following:

1. Layer -> Add Layer -> Add WMS/WTMS Layer

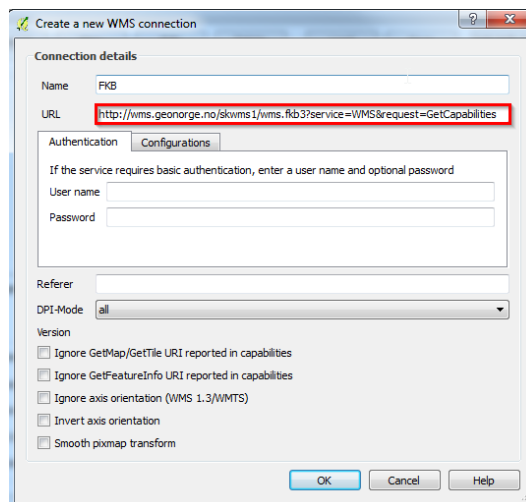


2. Add NEW service



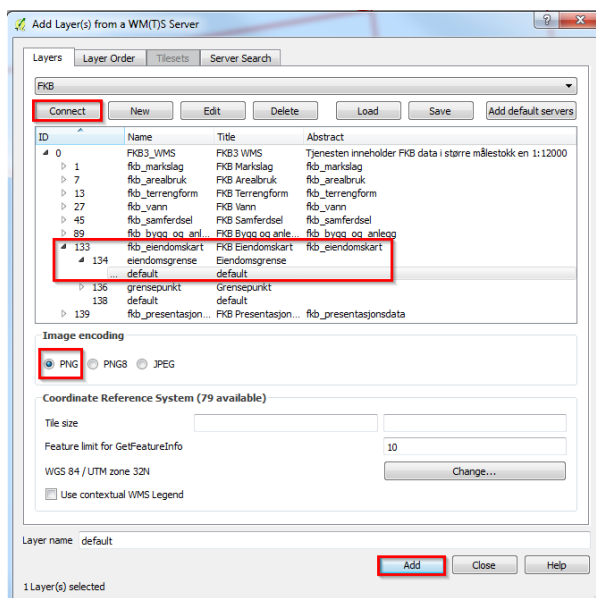
3. Type in link to a desired WMS server and name it accordingly. In our case type the following link to "FKB" WMS server.

<http://wms.geonorge.no/skwms1/wms.fkb3?service=WMS&request=GetCapabilities>



4. Click "connect"
5. Choose desired layers to be displayed in QGIS:

E.g. ID 134 for vector layers (example "Eiendomskart") – **IMPORTANT:** Choose PNG encoding



6. You can also add some other useful and freely available WMS services. These include the Norwegian Common Geo-Database “FKB”, where you find layers about data:
 - a. AR5 – land use
 - b. Contour lines
 - c. Water bodies
 - d. Transport network
 - e. Buildings
 - f. Properties
 - g. Object/city names and labels

<http://wms.geonorge.no/skwms1/wms.fkb3?service=WMS&request=GetCapabilities>

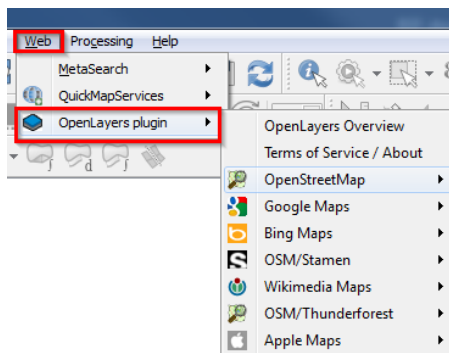
Please note: This data is freely available and the publisher GeoNorge reserves against the accuracy of the data - data could be outdated. Also note that some of these WMS layers are only visible at a certain extent (i.e. You have to zoom in/out in order for the map to be shown)

7. Alternatively, if you are a subscriber of “Norge-Digitalt lisens”, you can access the most accurate and up-to-date “Matrikkelen” WMS services of all Norwegian municipalities through GEONORGE.no webportal.

<http://wms.geonorge.no/skwms1/wms.matrikkel.v1?>

The satellite/aerial images are usually labelled with a year they were taken. It is a good practice to use a couple of images, preferably from different seasons of the year. This way you can see both the ground cover (on an autumn/winter image without leaves) and the canopy cover (on a spring/summer image).

8. For other FREE raster base-maps install Plugin “OpenLayers Plugin” (following instructions from 2.2 Required Plugins). After installing, make sure to add desired layers

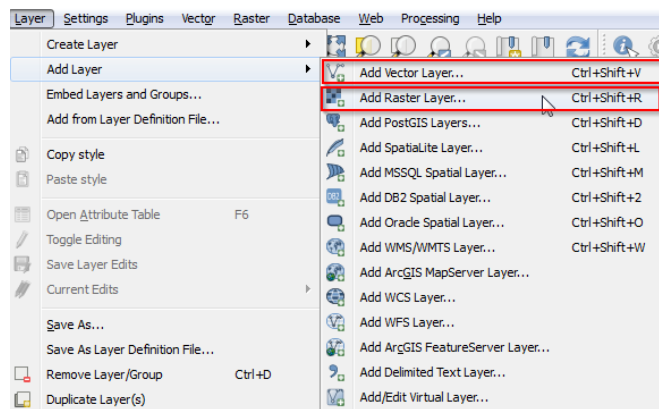


Another alternative of FREE raster base-maps is a plugin called “QuickMapServices”.

2.9 Adding raster / vector files from disk

If you want to use some other raster / vector files from your computer, follow this path:

1. Layer -> Add Layer -> Add Raster Layer / Add Vector Layer



2. Navigate to desired files. Most commonly used vector files are marked with file extension "*shp*", or shapefile. Raster files need to be georeferenced and the common file format is geoTIFF or "*tiff*".

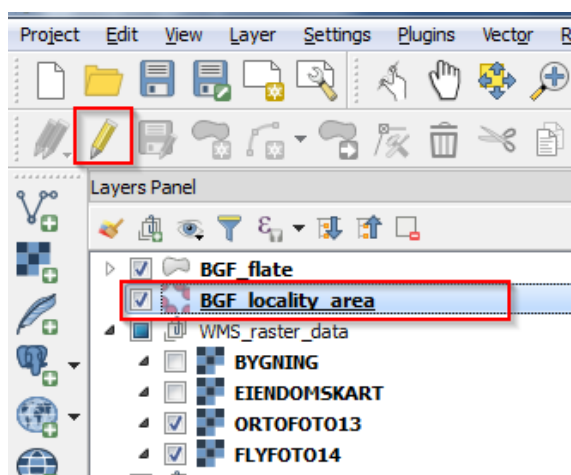
3 Mapping BGF Structures

The main part of this tutorial is about digitizing urban structures and determining their total BGF. The tutorial is divided into three parts in which you first outline your desired locality (for example: parcel bounded by property borders – in our case municipality directorate). Then you begin with mapping/describing each particular Blue-green Structure for this locality and finish by adding Additional Qualities. In this tutorial we will map the Governor's property in Ås.

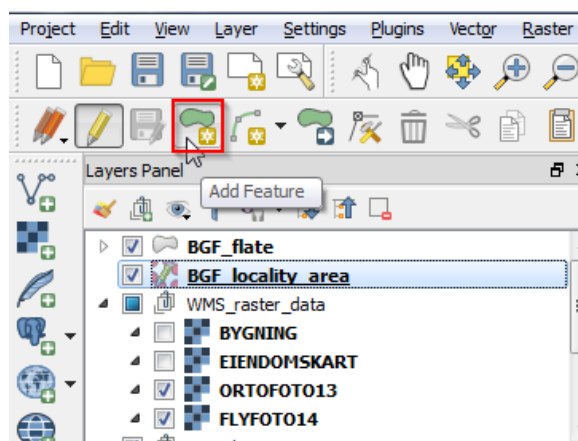
3.1 Locality level

This is where you delineate your locality. During this first part we will be working only within layer "BGF_locality_area". Thus, start by selecting layer "BGF_locality_area" in the Layers Panel
View -> Panels -> Layers Panel

1. Activate editing for the layer "BGF_locality_area", by clicking on the *"Toggle Editing"* pencil.

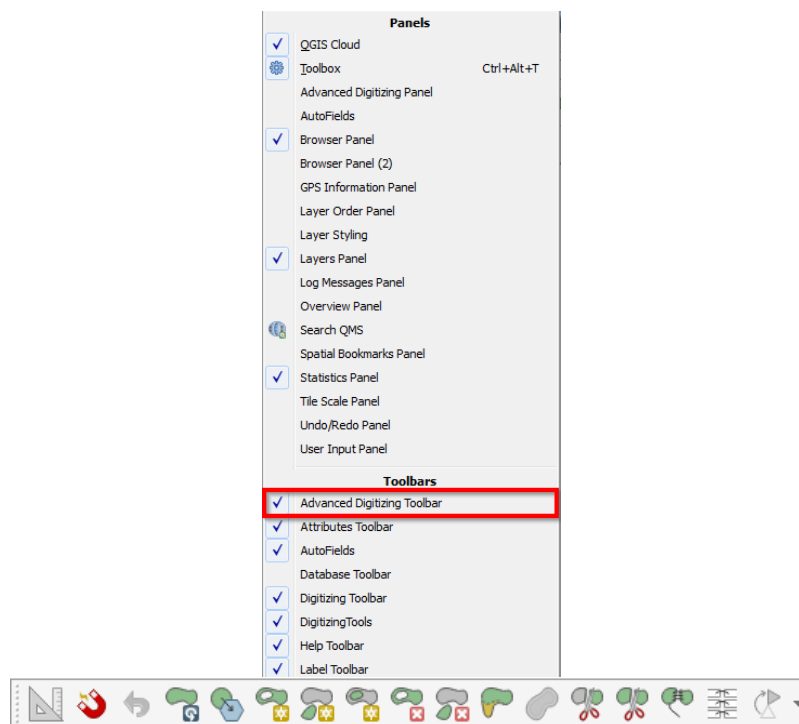


2. Click *"Add feature"* to add new polygon

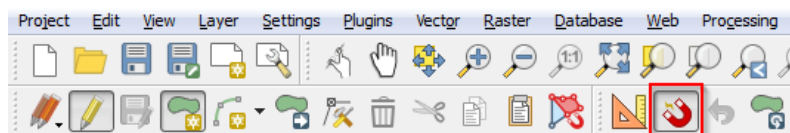


3. Begin digitizing

- a. Turn on ADVANCED DIGITISING TOOLBAR by right-clicking anywhere on the panels



- b. Use “Enable tracing” button to easily follow property boundaries of layer “0214_Eiendom teiggrense (Linje)”



- c. Begin by drawing polygon around the estate boundary clicking in each corner / all arcs of the polygon. Make sure your internet connection is working and that the map image is updated before continuing to digitise nodes of the polygon.




- d. Finish by right clicking inside created polygon. Fill in required information about ID and Locality_number (allowed values integer from 1 to 10)

BGF_locality_area - Feature Attributes

id	1
Locality Number	1
photo_loc	NULL
Locality Area (m^2)	17580.44

OK Cancel

- e. Optionally fill in overview photo of the locality (or fill it later with the “Identify Features”, see below).
- f. Press “OK”
- g. If you do not want to save the polygon select "cancel".

4. To see properties for a polygon use “Identify Features” button .

- a. **If editing mode is turned on, you can also edit the properties through “Identify Features” button.**
- b. Make sure to have “Auto open form” in the “Identify Results” enabled

Identify Results

Feature	Value
BGF...	
id	NULL
	NULL
	A4 Impermeable surfaces with drainage to a local close...
	0.1
	NULL
Blue-Green Surfaces	
Eg. concrete, asphalt, roof surfaces with runoff led to a...	
	NULL

Mode: Layer selection

View: Tree

☒ Auto open form

Help

5. To change corners/nodes, press "Node Tool"



- a. To add new nodes - double-click between two existing nodes where you want the new node to be created.
- b. To move nodes, mark the node (becomes blue square), then drag to the new position
- c. To remove points, mark the node (becomes blue square), then press "Back-space" on the keyboard.

6. To split a polygon into two use button "Split Features"



. Draw a split by cutting the polygon on both sides, then right-click.

7. To merge polygons

- a. you first have to select the polygons to be merged by using "Select Features"



(selected polygons are in yellow)

- b. join polygons with "Merge Selected Features" button

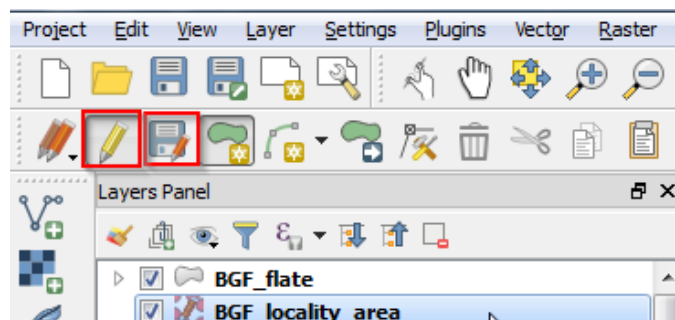


- c. Select which of the merged polygon's properties you want to maintain in the pop-up window (the properties that are retained appear in the row called "merge").

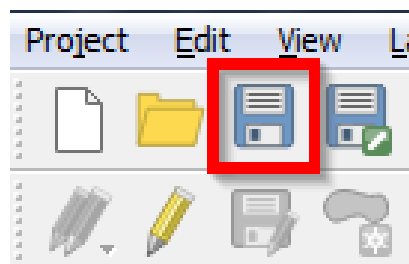
8. Use button "Save Layer edits" often



9. When done digitizing exit editing mode by clicking on "Toggle Editing" pencil.



10. Save the whole project by clicking on "Save" button





So far, there is a maximum limit of 10 localities within one open BGF-QGIS Project. If you need to map more localities, then you have to open another separate instance of QGIS


3.2 Other features


1. To zoom in / out, or move to a new location on the screen, use one of the buttons here:



2. Select polygon with . By drawing a square around polygons, all within the square is selected. Other ways of selecting polygons can be found by pressing on the black arrow.

3. Remove selection of selected polygons with 

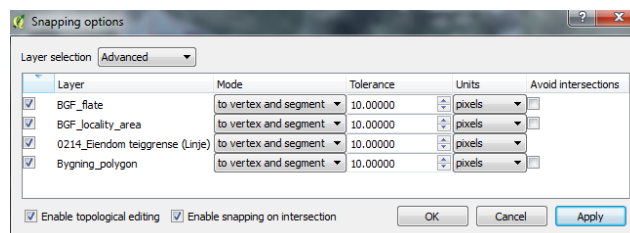
4. Delete a selected polygon by pressing 

5. Measure distance by  button. Choose "target line" on the black arrow if it does not come automatically).

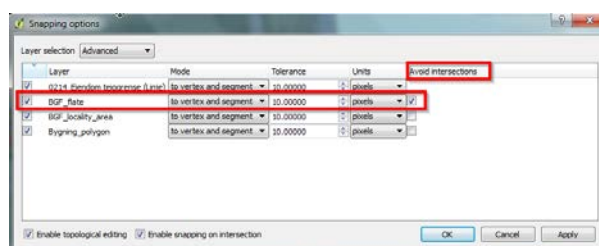
6. Measure area by  (choose "target area")

3.3 Snapping Options

1. Adjust snapping options (Settings -> Snapping Options) for the different stages of mapping process according to your needs (recommended value 10 pixel units).



2. It is also recommended to keep "avoid intersections" enabled for the first stage of mapping (BGF1 - Blue-Green Surfaces), as here we will have to cover the whole locality area without gap and overlap.



This way, when mapping a lawn around an already created building polygon, this will be clipped away automatically.



3. For the second stage of mapping (BGF2 - Additional Qualities) you must have “*avoid intersections*” **disabled**. This is important to be able to place/map additional qualities on top of Blue-Green Surfaces (enable overlaps).

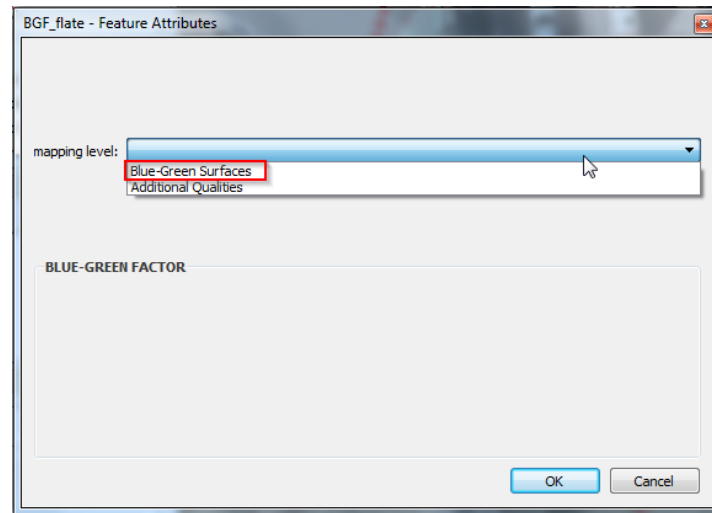
3.4 BGF1 – Blue-Green Surfaces

The main part of the project is to map Blue-Green Structures within a locality. You do that by assigning BG factor attributes to each mapped polygon. The mapping is divided into two stages BGF1 mapping surfaces and BGF2 mapping additional qualities.

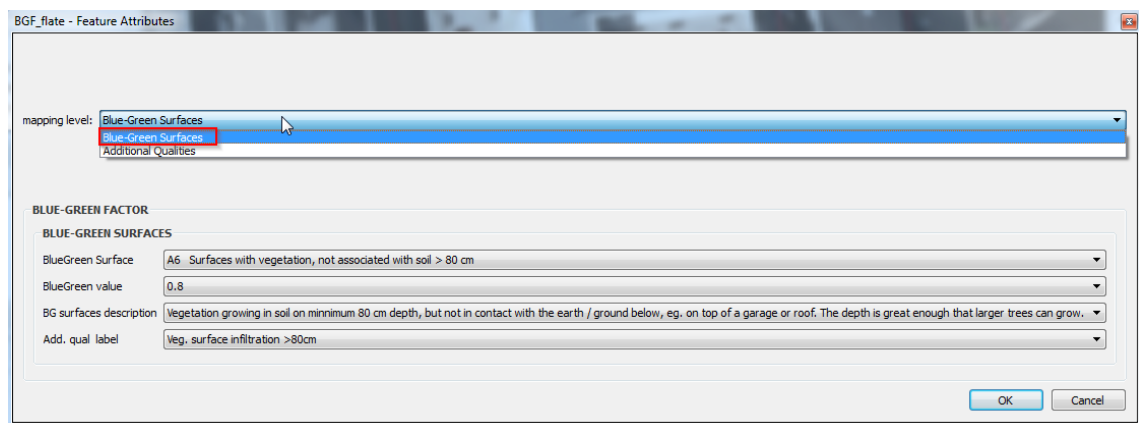
1. Digitizing BGF inside LOCALITY 1
 - a. Select layer “BGF_flats”
 - b. Repeat steps 1 (turn on edits) and 2 (add new polygon) as in section 4.1 Locality level
2. Start with digitizing large structures in the Blue-Green Surfaces - BGF1 level (see section 4.6 STRUCTURE below.)
 - a. You can use the raster layer “Bygning_polygon” to help you with digitizing building structures



- Choose option “Blue-Green Surfaces” after finishing drawing a polygon



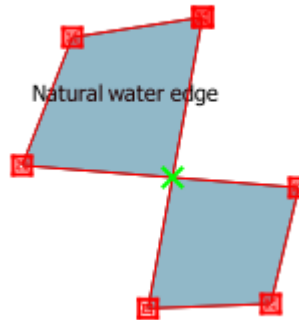
- Based on your choice, new menus will become available.



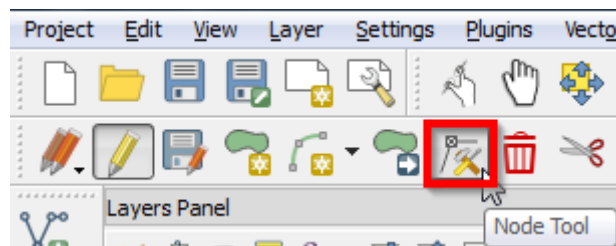
- According to the structure, choose one of the 9 available Blue-Green Surface types. Use description to know more about the BG surface type. To confirm polygon creation click on “OK”.
- Polygon with a label will show up on your map



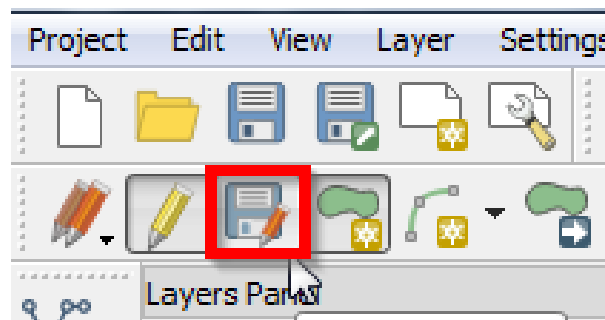
7. Inspect created polygon for mistakes and topology errors (green cross instead of a red node)
 - a. Topology errors should be avoided at all costs. To learn about what happens when you have topology errors see section 4.7 Topology checker.



8. Adjust vertices in case necessary

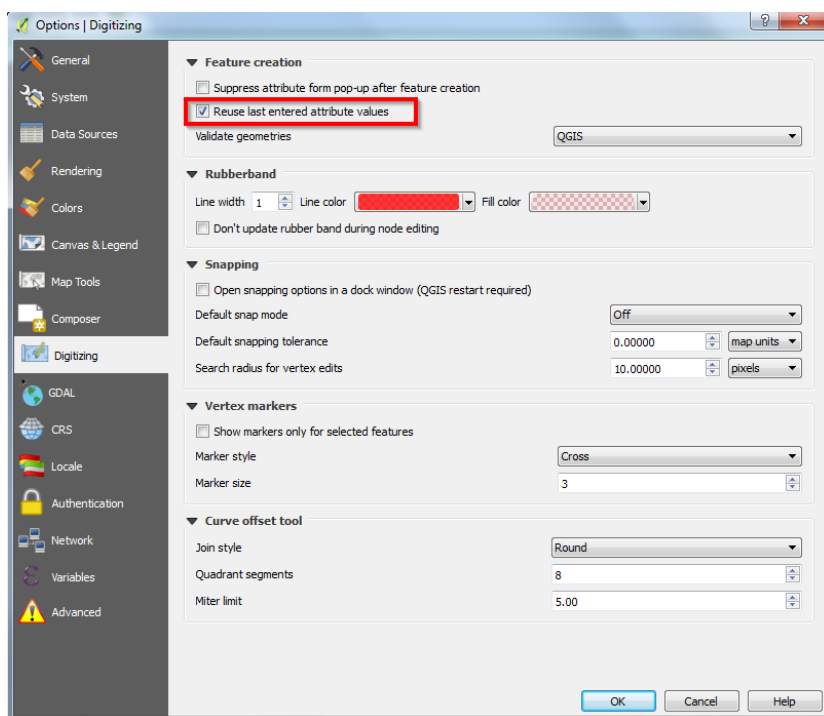


9. Save edits to the "BGF_flate" layer often. This helps you not losing your data and to update information in the attribute table.



10. It is important to map the whole area of each locality using one of the Blue-Green Surfaces before you start adding Additional Qualities. This is because the blue-green factor is standardised by the total property area. If some surfaces are left out it will bias the overall BGF downward

11. In order to reuse the attributes from the previously mapped polygon, go to Settings -> Options -> Digitizing -> “Reuse last entered attribute values”



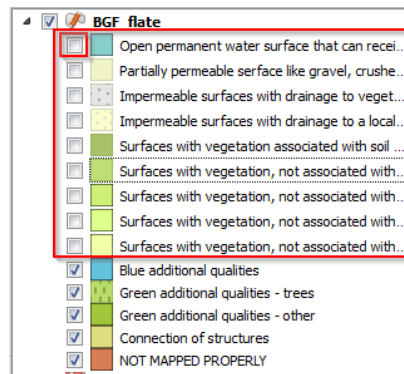
12. Optionally you can check the progress of you mapping by hitting the “Show Statistical Summary” button on the Attributes toolbar (and choosing the correct layer i.e. “BGF_flate” to display summary for)



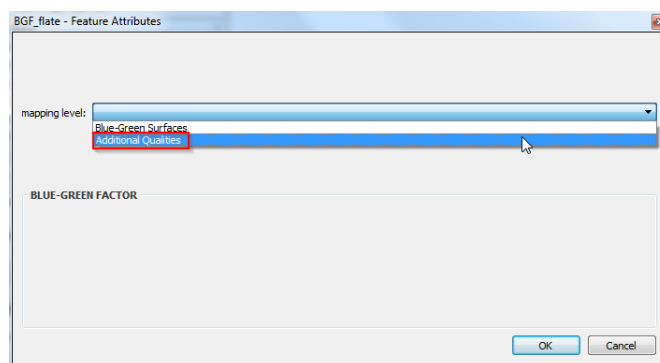
3.5 BGF2 - Additional Qualities.

Additional qualities are mapped on top of Blue-Green Structures, and thus can overlap. If you have enabled “avoid intersections” (step 3. in section 4.2 you have to turn it back OFF for layer “BGF flate”.

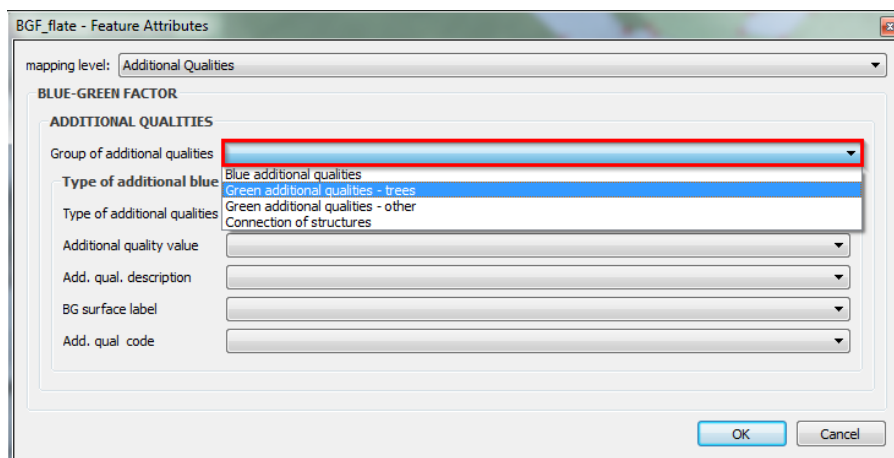
For better visual inspection of the aerial image for Additional qualities, you might want to turn off “visibility” of some of the already mapped polygons from BGF1 level. You do this in the Layers Panel.



1. In the dropdown menu for mapping level, choose Additional Qualities (see section 4.8 STRUCTURE below.)

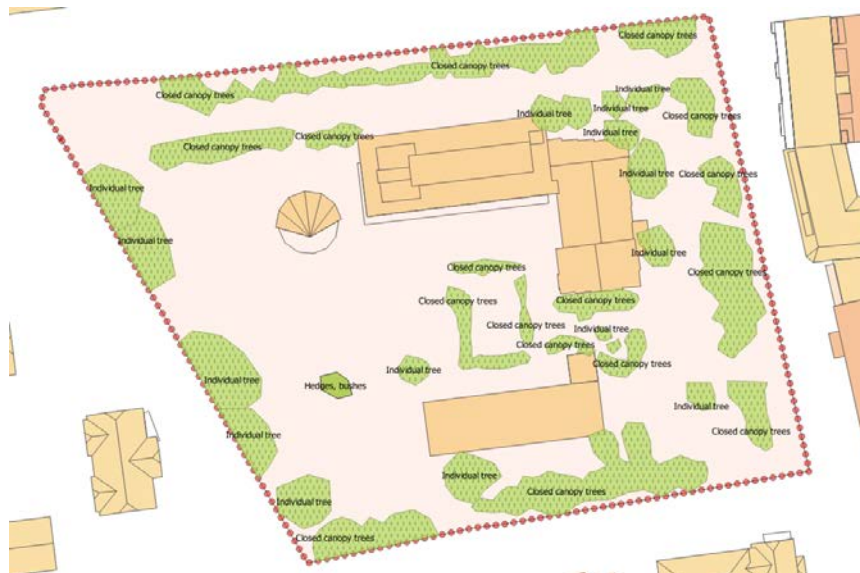


2. Select corresponding group of additional qualities from four available options



- Finally, when all desired information is filled based on your choice. Click on “OK” to create polygon.

- At the end, you should end up by digitizing all Additional Qualities of a locality.



- In many cases already mapped surfaces will also take on qualities in the same polygon, f.ex. green space > 75m². To copy an existing polygon from BGF1 - Blue-Green Surfaces, and assigning it an BGF2 – Additional quality value, first select the chosen polygon with “Select” button. Then click “Copy” button (or Ctrl+C) and subsequently “Paste” button (or Ctrl+V). The polygon is now be copied over the original one (Note: “Avoid intersections” in snapping options have to be unclicked).



Now press “Identify Features” button to adjust attributes for the newly created polygon.

- IMPORTANT:** If, after you have created a polygon, it does not have a label or is coloured with red “NOT MAPPED PROPERLY”, you have to check and correct it. Python-

init function in QGIS forms should also warn you about such cases before they are entered.



The reason is that not all the required fields have been filled and thus the BGF cannot be calculated. Make sure to fill attributes before clicking OK.

The image shows the 'BGF_flate - Feature Attributes' dialog box. The 'mapping level' is set to 'Blue-Green Surfaces'. Under the 'BLUE-GREEN FACTOR' section, the 'BLUE-GREEN SURFACES' sub-section is expanded, showing five dropdown menus: 'BlueGreen Surface', 'BlueGreen value', 'BG surfaces description', 'Add. qual label', and 'BG surface code'. These dropdown menus are highlighted with a red box. The 'OK' button is crossed out with a red 'X', and the 'Cancel' button is visible.

Future improvements:

BGF1 and BGF2 will be available as two separate layers, which will simplify the attribute table and make the form value relation unnecessary. We plan on using Spatialite or GeoPackage and then having spatial views for aggregating data into the locality level.

3.6 Structure overview

The following lists the blue-green structures implemented in the BGF methodology.

BGF1 Blue-Green Surfaces

- A. Blue-Green Surfaces
 - A1. Open permanent water surface that can receive rainwater
 - A2. Partially permeable surface like gravel, crushed stone, and reinforced grass surface
 - A3. Impermeable surfaces with drainage to vegetated areas or an open drainage magazine
 - A4. Impermeable surfaces with drainage to a local closed storm water drainage
 - A5. Surfaces with vegetation associated with soil or bedrock
 - A6. Surfaces with vegetation, not associated with soil > 80 cm
 - A7. Surfaces with vegetation, not associated with soil 40 - 80 cm
 - A8. Surfaces with vegetation, not associated with soil 20 - 40 cm
 - A9. Surfaces with vegetation, not associated with soil 5 -20 cm

BGF2 Additional qualities

- B. Blue additional qualities
 - B1. Natural edges to water surfaces
 - B2. Rain bed or equivalent
- C. Green additional qualities - tree canopy
- D. Green additional qualities - other
 - D1. Native vegetation
 - D2. Hedges, bushes and multi-stemmed trees
 - D3. Green walls
 - D4. Perennials and other ground cover
 - D5. Contiguous green areas over 75 m²
- E. Connectivity of structures (filled in with the number 0,05)
 - E1. Connectivity to an existing Blue-green structure.

3.7 Topology checker

It is important that the topology in the map be correct! Errors often appear with a green cross:




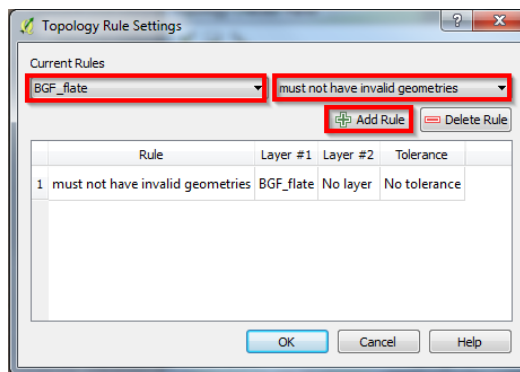
Or when you see such orange warning about GEOMETRY ERRORS.




Failure in topology causes problems with snapping, and should be corrected as soon as they occur.

Errors can often be corrected by moving or deleting additional (green) nodes

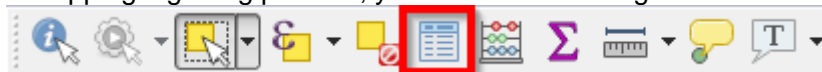
- 1) You can check for errors in topology by navigating into
 - a. Vector -> "Topology checker"
- 2) Add topology rules by pressing . Using the rules you set a verification procedure checks already created polygons for errors. The rules must be added for the layer "BGF_flare".



- a. Useful rules are "must not have invalid geometries"
 - b. and "must not have gaps".
- 3) Check if the topology of your map is correct by pressing .
- 4) BGF for polygons with invalid geometries will still be calculated. However, it will not be possible to further snap towards this incorrectly created polygon.


4 Browsing through registered data

Throughout the mapping/digitizing process, you can check the registered data in attribute table.



For example it is useful to check for the polygon area, polygon BGF or the final BGF for the whole locality. Otherwise, you find all the data about BGF type codes, descriptions, labels or percentage of mapped area.

You can go back and change some of the attributes by using “*Identify Features*” button .

To check statistical summary of registered data use  button (for more info, see 10.4 - How to calculate simple statistics for total BGF score)

The following fields are being registered while you digitize BGF into polygons. Each of the fields has its function in final calculation of BGF. (see section APPENDIX for more details about code used.)

Attribute name	Attribute Description
Id	ID number
1_BG_surf	Blue-Green Surface
1_BG_val	Blue-Green Surface Value
2_BG	Group of Additional Qualities
2_BG_type	Additional Quality type
2_BG_val	Additional Quality Value
0_BG_level	BGF level
1_BG_descr	Blue-Green Surface – Description
2_BG_descr	Additional Qualities – Description
Photo	link to picture of polygon
2_BG_label	Additional Qualities – Label
1_BG_label	Blue-Green Surface – Label
1_BG_lab_c	Blue-Green Surface - Label shortcut
2_BG_lab_c	Additional Qualities - Label shortcut
BGF_locality_area_loc_area	Locality area
Area	Polygon total area (in m ²)
BGF1	BGF for Blue-Green Surface polygons
BGF2	BGF for Additional Quality polygons
BGF_Code	BGF code
Loc_num	Locality number
tot_BGF1	Total BGF1 - surfaces for each locality
tot_BGF2	Total BGF2 - additional qualities for each locality
MappedArea	fraction of mapped area/total area
E1_connect	Connectivity found? (Y/N)
BGF_final	Final BGF score for each locality
BGF_contrb	Per-cent contribution of a given polygon to the total locality BGF

5 Final BGF score

The most important part of the whole mapping and digitizing is a final score for Blue-Green Factor for each locality. This value is displayed in the last column of attribute table "BGF_final". The value is specific for each locality, but same for each mapped polygon within a locality.

BGF_flat :: Features total: 64, filtered: 64, selected: 0

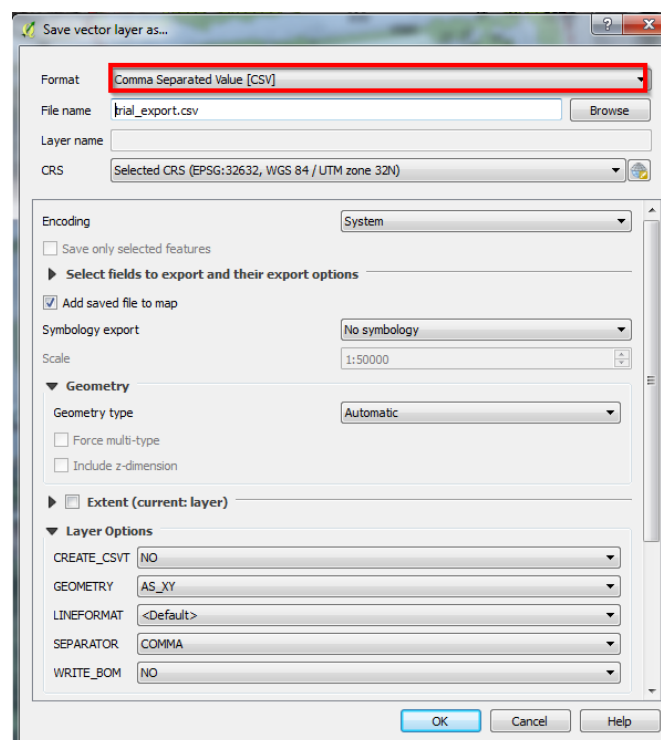
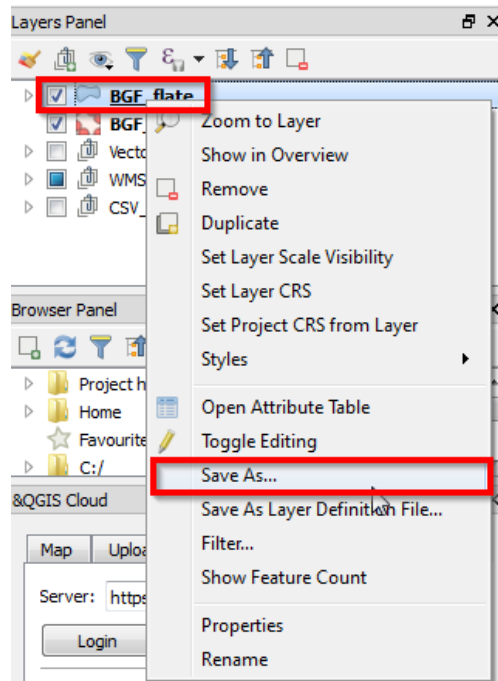
	Locality_number	mapped area/total area	Polygon Photo	BG surface label	Add. qual label	E1_connect	BG surface code	Add. qual code	BGF_final
49	1	1.988		NULL	Drainage to grou...	NULL	DGW	NULL	0.833
50	1	1.988		NULL	Impermeable ope...	NULL	IOD	NULL	0.833
51	1	1.988		NULL	Drainage to grou...	NULL	DGW	NULL	0.833
52	1	1.988		NULL	Drainage to grou...	NULL	DGW	NULL	0.833
53	1	1.988		NULL	Drainage to grou...	NULL	DGW	NULL	0.833
54	1	1.988		NULL	Drainage to grou...	NULL	DGW	NULL	0.833
55	1	1.988		NULL	Drainage to grou...	NULL	DGW	NULL	0.833
56	1	1.988		NULL	Drainage to grou...	NULL	DGW	NULL	0.833
57	1	1.988		NULL	Drainage to grou...	NULL	DGW	NULL	0.833
58	1	1.988		NULL	Impermeable ope...	NULL	IOD	NULL	0.833
59	1	1.988		NULL	Impermeable ope...	NULL	IOD	NULL	0.833
60	2	1.000		NULL	Impermeable clos...	NULL	ICD	NULL	0.472
61	2	1.000		NULL	Impermeable clos...	NULL	ICD	NULL	0.472
62	2	1.000		NULL	Impermeable ope...	NULL	IOD	NULL	0.472
63	2	1.000		NULL	Vegetation+soil ...	NULL	VS80	NULL	0.472
64	1	1.988		Individual tree	NULL	NULL	NULL	SMT	0.833

Show All Features

The field "BGF_contrb" registers the per-cent contribution of a given polygon to the final BGF factor.

6 Export of registered data

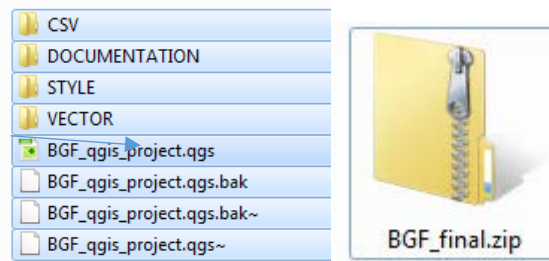
Right click on the layer that you want to export and choose “Save as”. Choose “Comma separated value [CSV]” format



Your project database is now saved as CSV file, which you can open statistical software and MS Excel). The statistical package “R” can read dbase files directly.

IMPORTANT: If you are to share your whole project (not only output), it is important to attach all necessary files. This means not just the “project.qgs” file, but all vector, raster and table data.

The easiest way is to Use QConsolidate (if you did not use server-databases that may become inaccessible).

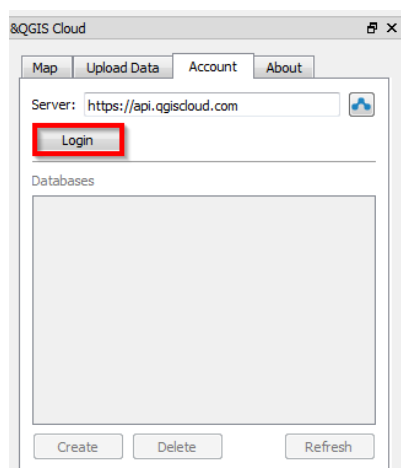


7 Sending your data to CLOUD

If you have installed the optional plug-in QGIS Cloud Plugin during step 2.5 *Optional Plugins*, you only need to create a free account to share your data with other QGIS users. You do this by following instructions on the sign up page of QGIS Cloud (https://qgiscloud.com/en/account/sign_up).

Now you have to enable the QGIS Cloud Plugin through View -> Panels -> QGIS Cloud.

After creating an account you sign in using your credentials into QGIS Cloud Plugin through QGIS



By sending your data to the QGIS cloud you can share it with your colleagues or make it available to the public.

When uploading your data to the QGIS Cloud, keep in mind which of your layers might have restrictions on being publicly shared (ex: some raster layers or property data).

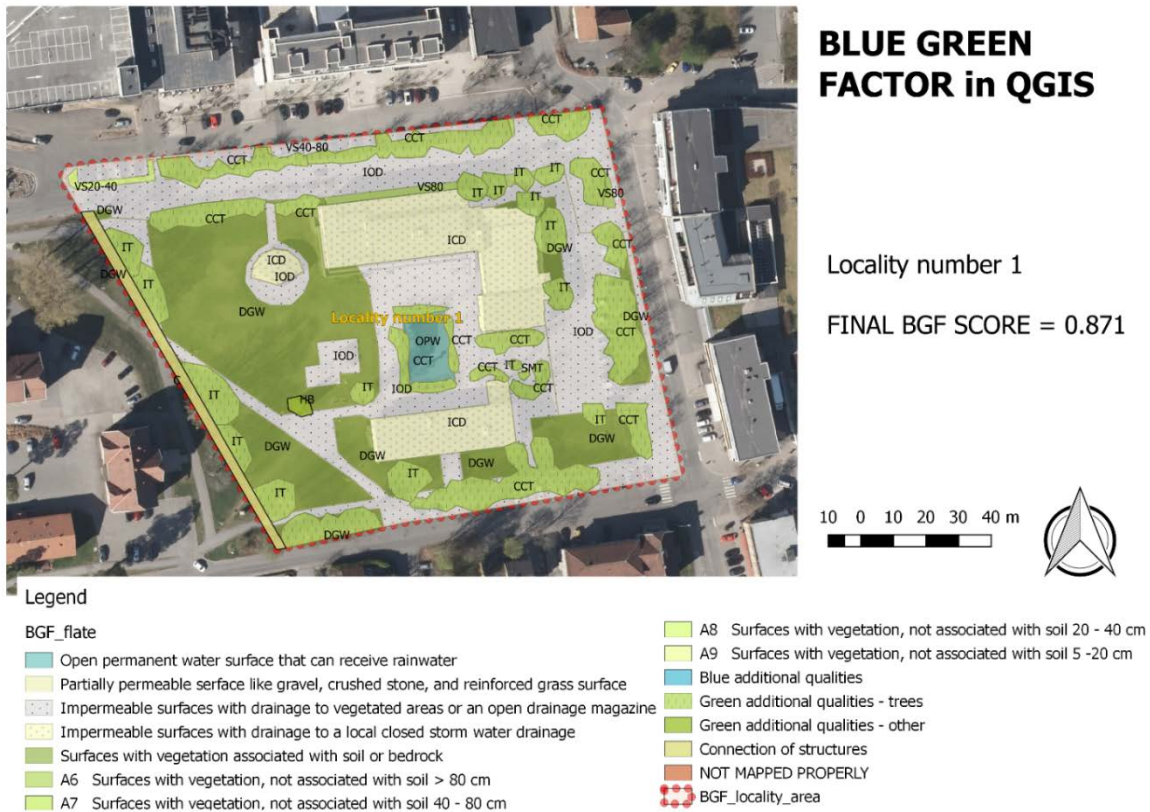
8 Communicating your results

8.1 Map output (Print Composer)

Usually, the process does not end by mapping an area for BGF. Some sort of output is required. You can present your data in several ways. For example by producing a Map Layout in “*Print Composer*”. Learn more about how to create layouts in the QGIS Tutorials:

https://docs.qgis.org/2.0/en/docs/user_manual/print_composer/print_composer.html

Example output Map of the Ås Municipality area:



Many other customization options exist in QGIS. You can change the colour scheme or labels and tweak your final map layout into perfection. (see hints and tutorials below)

http://docs.qgis.org/2.0/ca/docs/training_manual/basic_map/symbology.html

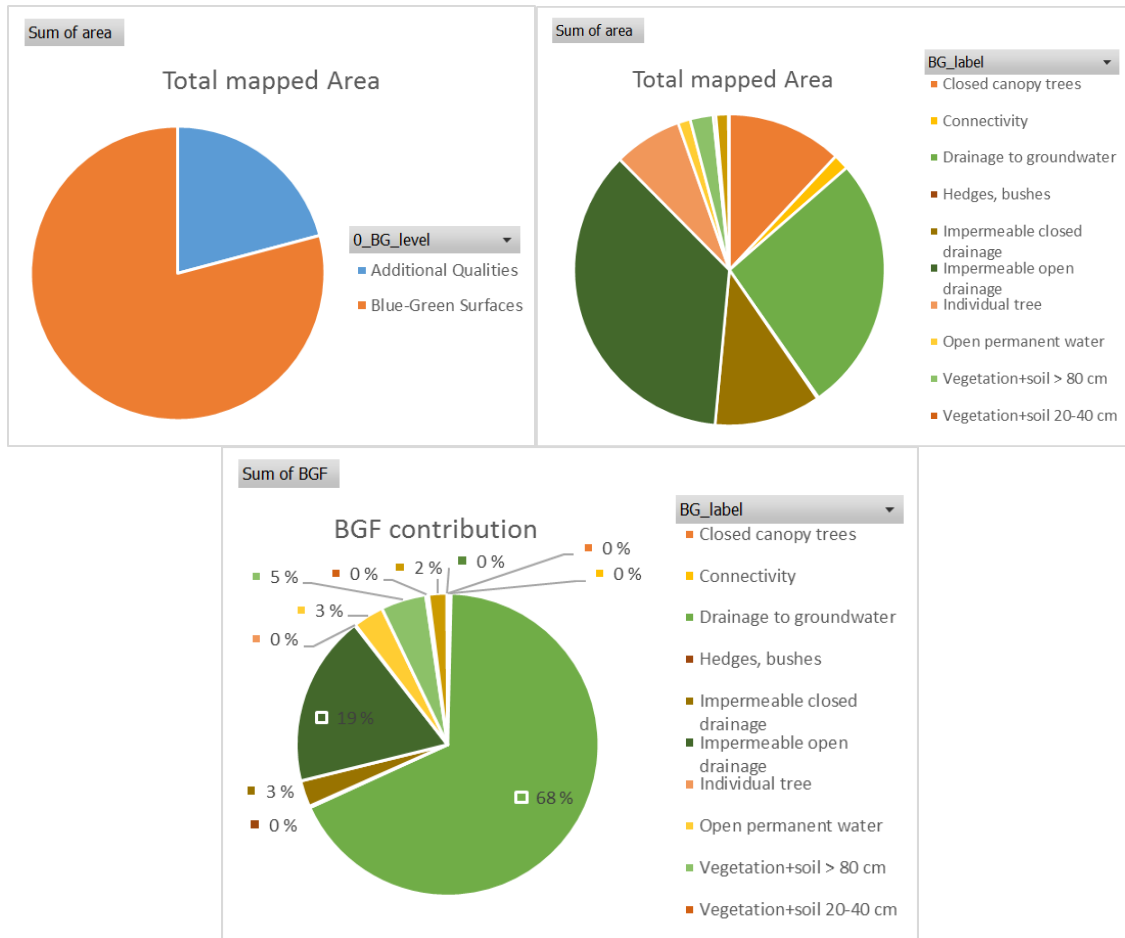
http://docs.qgis.org/2.0/ca/docs/training_manual/vector_classification/label_tool.html

<https://gis.stackexchange.com/questions/3083/what-makes-a-map-beautiful>

8.2 Data output (Excel, R, Matlab ...)

You can also export your final data into a CSV table (as shown in section 7 Export of registered data) and analyse them with your favourite statistical program. (Advanced users can also do analyses without data export within QGIS, e.g. using R script in Processing or statistical summary plugin.)

Here we produce summary diagrams in Excel. Some examples are provided below, but depends only on your imagination/needs. NOTE: you will have to do some data clean-up before analysis.



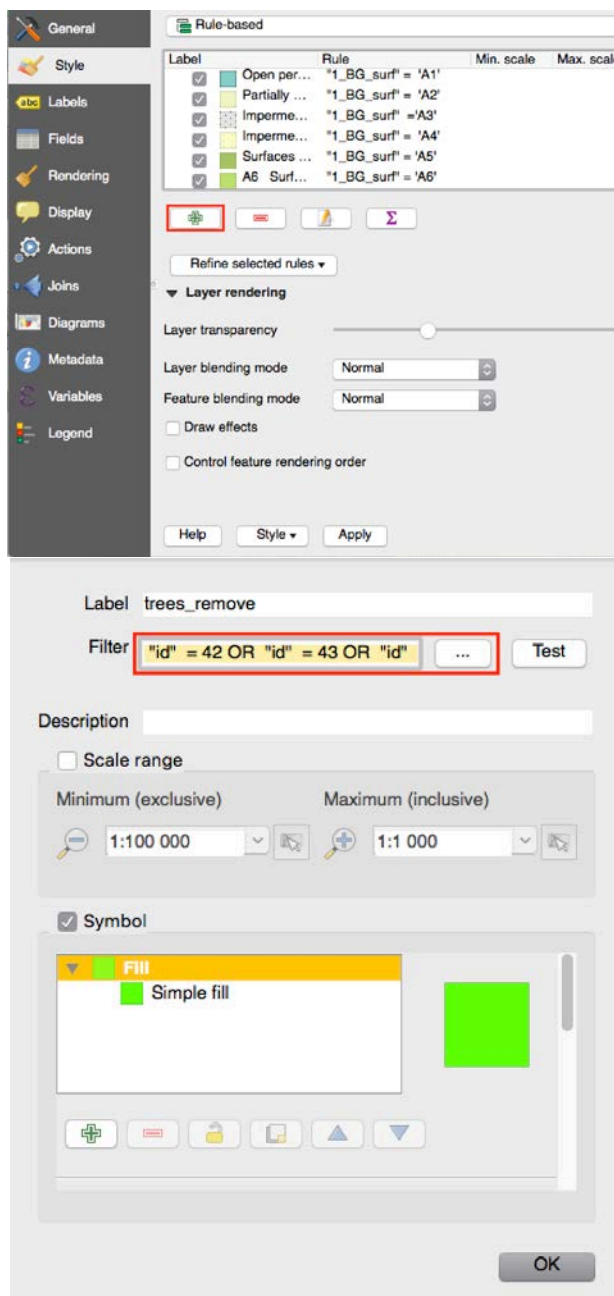
8.3 Highlighting selected features of your project – focusing your message

In some cases you may wish to highlight some blue or green features in the map of your locality. For example, it could be that a selection of trees on the property will be cut, perhaps to be compensated with the same or larger tree canopy elsewhere with newly planted trees. You wish to highlight these qualities in a separate map, and calculate the BGF score only for this subset of qualities (in order to illustrate the amount of BGF that needs to be compensated).

First, select the features you wish to highlight (e.g. individual trees) by identifying on the map, or by their attributes.

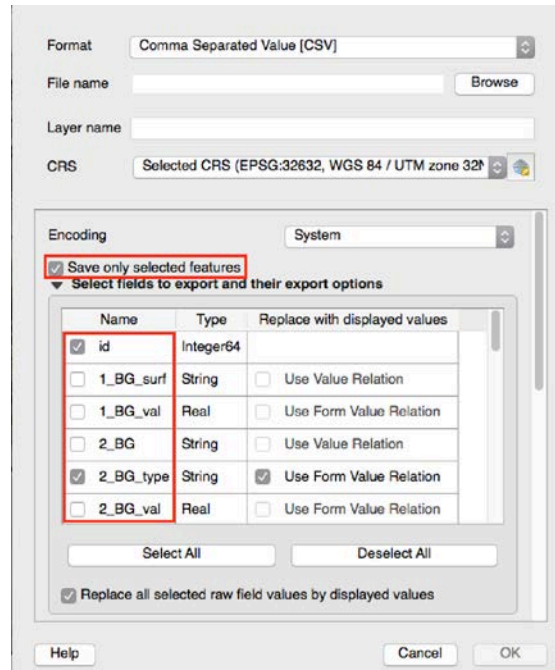
1. To extract attributes of the selected features with selected fields for calculation

a. You can select features either by attributes

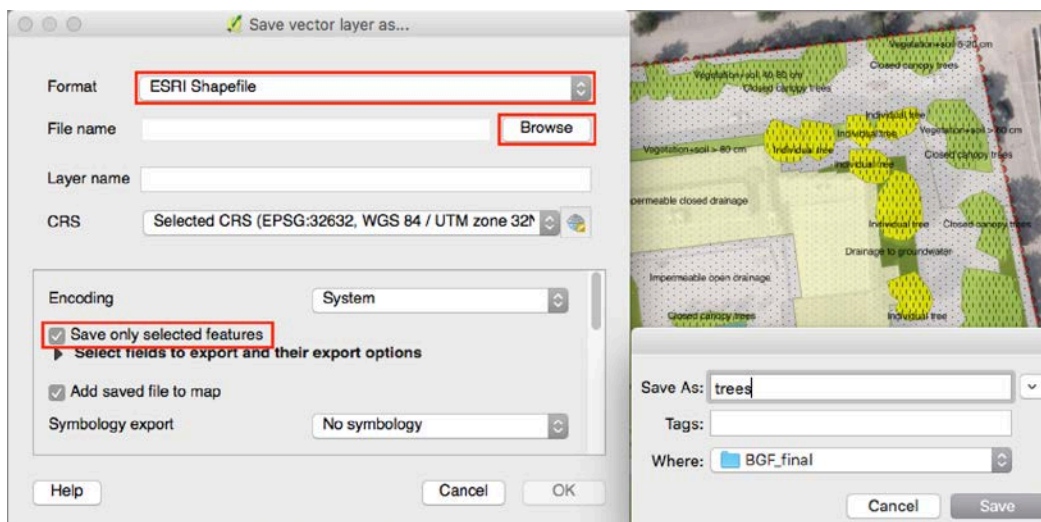


b. Or select manually

2. Save selected features as CSV, see section “7 Export of registered data” in this manual. Additionally tick “*Save only selected features*” and unselect the fields you don’t need in the list of “Select fields to export”:



3. Alternatively you can create a new layer from selected features
 - a. Select the features you wish to highlight
 - b. Right click the “BGF_flate” layer -> Save as:



- c. Choose ESRI Shapefile as Format. Other formats can be found at <http://switch-fromshapefile.org/>
- d. Click Browse for File Name, where you name this new layer with selected features, e.g. “trees”, and choose where you want to store the new vector layer
- e. Tick save only selected features.

By doing this, you create a GIS shapefile stored as several specific files.

Now you have a subset of the “BGF_flate” with only the selected features, where you can either extract attribute table or define how you highlight them. More instructions for setting symbology see section 9.1 Map output (Print Composer).

An example of the outcome of highlighting selected features in 2 ways with Ås Municipality area:



9 Adjusting advanced settings in BGF-QGIS project

It is possible to make changes to the internal “core” information for BGF-QGIS system. In particular criteria can be added/removed/edited and the weighting can be changed. All this core information is stored in CSV files inside folder “CSV”.

9.1 How to restore default layer style again

If any unwanted changes have happened in BGF_flare layer (for example colors, labels or calculations have changed), you can load a layer style from a previously saved file. Do this by navigating into “BGF_flare” layer (in layers panel) -> layer properties -> Style (button in the lower left corner) -> load Style. Now navigate to style file in our project folder and subsequently subfolder “BGF_final_clear” -> “STYLE” -> “bgf_final_10.qml”

9.2 How to add, remove, edit description of BGF-QGIS criteria.

All values and names are stored in file folder named “CSV” in the files “0_EN.csv”, “1_EN_bluegreen_areas.csv”, “2_EN.csv” and “BGF_EN.csv”. In case you decide to adjust some of the information (description, new parameters), this can be done through changing one of the abovementioned files. Notice that the QGIS project needs to be closed (and saved) at this point.

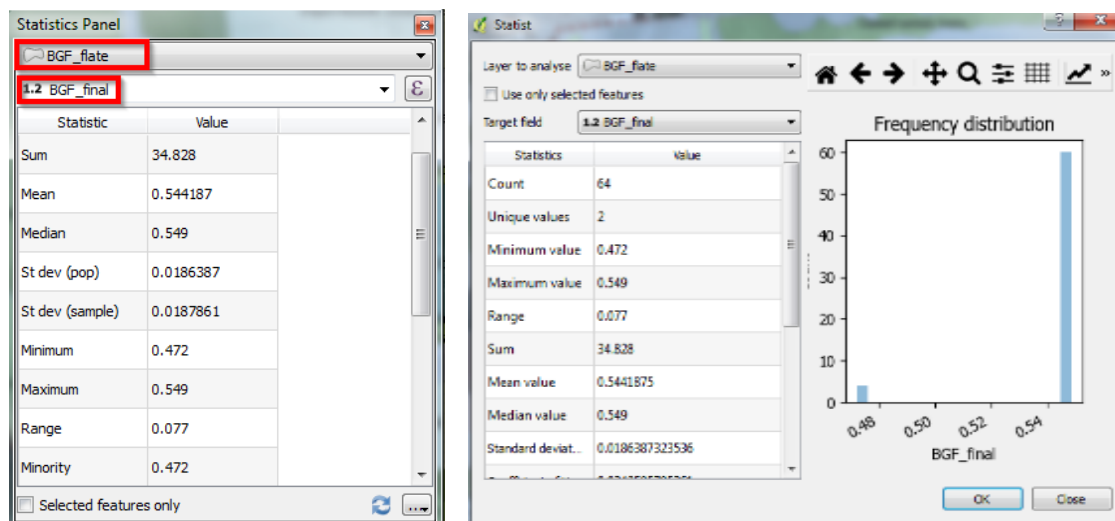
9.3 How to change weighing of BGF

In case you decide to adjust weighing system of BG surfaces, this can be done through changing file named “BGF_EN.csv” in file folder CSV. Notice that the QGIS project needs to be closed (and saved) at this point. After opening the file “BGF_EN.csv”, change appropriate weights in column “value” for given Blue-Green Surface or Additional Quality.

9.4 How to calculate simple statistics for total BGF score

Choose

View -> Panels -> Statistics Panel.

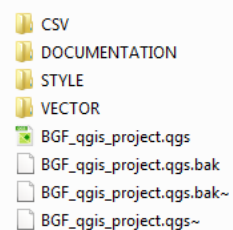


OPTIONAL: To display a histogram of values for a desired field in addition to basic statistics, you can use plugin “Statist” (which you install using same procedure as mentioned during step 2.2 *Required Plugins*).

9.5 File structure in the MAIN folder

MAIN folder is named “BGF_final” and inside you find the following sub-structure

- CSV – contains all spreadsheet tables with data
- DOCUMENTATION – tutorial for use of the BGF-QGIS project
- STYLE – QGIS style file for “BGF_flate” layer containing field structure, label and colour coding
- VECTOR – all vector files used in the project (ex: BGF_flate, BGF_locality_area, property borders)
- BGF_qgis_project.qgs – project file to be OPENED



Future improvements:

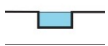
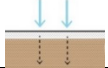


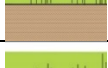
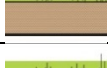
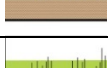

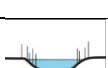
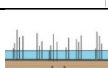




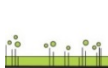


We plan on using Spatialite DB instead of the current filesystem. This way all data (except documentation) can be stored in SQL format. This will allow also spatial views for aggregation and make some of the plugins unnecessary.

10 References

Framtidens Byer (2014) Blågrønn faktor. Veileder byggesak. Hoveddelen 28.01.2014. 2014, Plan og bygningsetaten, Bærum Kommune, Dronninga Landskap, COWI, C.F. Møller.

11 APPENDIX

11.1 Abbreviations, description and diagram for BGF structures in BGF-QGIS

Code	Short label	Description	Value	Picture
A1	OPW	Open permanent water surface that can receive rain-water	1	
A2	PP	Partially permeable surface like gravel, crushed stone, and reinforced grass surface	0.3	
A3	IOD	Impermeable surfaces with drainage to vegetated areas or an open drainage magazine	0.2	
A4	ICD	Impermeable surfaces with drainage to a local closed storm water drainage	0.1	
A5	DGW	Surfaces with vegetation associated with soil or bed-rock	1	
A6	VS80	Surfaces with vegetation, not associated with soil > 80 cm	0.8	
A7	VS40-80	Surfaces with vegetation, not associated with soil 40 - 80 cm	0.6	
A8	VS20-40	Surfaces with vegetation, not associated with soil 20 - 40 cm	0.4	
A9	VS5-20	Surfaces with vegetation, not associated with soil 5 - 20 cm	0.2	
B1	NWE	Natural edges to water surfaces	0.3	
B2	RB	Rain bed or equivalent	0.3	
C1	CCT	Tree canopy	(% of total area)	
D1	NV	Native vegetation	0.6	
D2	HB	Hedges, bushes and multi-stemmed trees	0.4	
D3	GW	Green walls	0.4	
D4	PP	Perennials and other ground cover	0.3	
D5	GA	Contiguous green areas over 75 m2	0.1	
E1	C	Connection to an existing Blue-green structure.	0.05	

11.2 Code used in calculations of virtual fields:

```

#### BGF1
$area * "1_BG_val"

#### BGF2
CASE
  when "2_BG_type" = 'C1'
  then ($area / "BGF_locality_area_loc_area" ) * 100
  when "2_BG_type" = 'C2'
  then ($area / "BGF_locality_area_loc_area" ) * 100
  else $area * "2_BG_val"

END

#### BGF_CODE1
concat(
  left( "1_BG_surf" , 1) ,
  left( "2_BG_type" , 1)
)

#### LOC
geomintersects( 'BGF_locality_area', 'loc_number')

#### tot_BGF1
CASE
  when "loc_num" = 1
  then aggregate( 'BGF_flate', 'sum', "BGF1",filter:="loc_num"=1 )
  when "loc_num" = 2
  then aggregate( 'BGF_flate', 'sum', "BGF1",filter:="loc_num"=2 )
  when "loc_num" = 3
  then aggregate( 'BGF_flate', 'sum', "BGF1",filter:="loc_num"=3 )
  when "loc_num" = 4
  then aggregate( 'BGF_flate', 'sum', "BGF1",filter:="loc_num"=4 )
  when "loc_num" = 5
  then aggregate( 'BGF_flate', 'sum', "BGF1",filter:="loc_num"=5 )
  when "loc_num" = 6
  then aggregate( 'BGF_flate', 'sum', "BGF1",filter:="loc_num"=6 )
  when "loc_num" = 7
  then aggregate( 'BGF_flate', 'sum', "BGF1",filter:="loc_num"=7 )
  when "loc_num" = 8
  then aggregate( 'BGF_flate', 'sum', "BGF1",filter:="loc_num"=8 )
  when "loc_num" = 9
  then aggregate( 'BGF_flate', 'sum', "BGF1",filter:="loc_num"=9 )
  when "loc_num" = 10
  then aggregate( 'BGF_flate', 'sum', "BGF1",filter:="loc_num"=10 )
  else NULL
END

#### tot_BGF2
CASE
  when "loc_num" = 1
  then aggregate( 'BGF_flate', 'sum', "BGF2",filter:="loc_num"=1 )
  when "loc_num" = 2
  then aggregate( 'BGF_flate', 'sum', "BGF2",filter:="loc_num"=2 )
  when "loc_num" = 3
  then aggregate( 'BGF_flate', 'sum', "BGF2",filter:="loc_num"=3 )
  when "loc_num" = 4
  then aggregate( 'BGF_flate', 'sum', "BGF2",filter:="loc_num"=4 )
  when "loc_num" = 5
  then aggregate( 'BGF_flate', 'sum', "BGF2",filter:="loc_num"=5 )
  when "loc_num" = 6
  then aggregate( 'BGF_flate', 'sum', "BGF2",filter:="loc_num"=6 )
  when "loc_num" = 7
  then aggregate( 'BGF_flate', 'sum', "BGF2",filter:="loc_num"=7 )
  when "loc_num" = 8
  then aggregate( 'BGF_flate', 'sum', "BGF2",filter:="loc_num"=8 )
  when "loc_num" = 9
  then aggregate( 'BGF_flate', 'sum', "BGF2",filter:="loc_num"=9 )
  when "loc_num" = 10
  then aggregate( 'BGF_flate', 'sum', "BGF2",filter:="loc_num"=10 )

```



```

    else NULL
END

#### mapped area
CASE
  when "loc_num" = 1
  then aggregate( 'BGF_flate', 'sum', "area", filter:="loc_num"=1 ) / "BGF_locality_area_loc_area"
  when "loc_num" = 2
  then aggregate( 'BGF_flate', 'sum', "area", filter:="loc_num"=2 ) / "BGF_locality_area_loc_area"
  when "loc_num" = 3
  then aggregate( 'BGF_flate', 'sum', "area", filter:="loc_num"=3 ) / "BGF_locality_area_loc_area"
  when "loc_num" = 4
  then aggregate( 'BGF_flate', 'sum', "area", filter:="loc_num"=4 ) / "BGF_locality_area_loc_area"
  when "loc_num" = 5
  then aggregate( 'BGF_flate', 'sum', "area", filter:="loc_num"=5 ) / "BGF_locality_area_loc_area"
  when "loc_num" = 6
  then aggregate( 'BGF_flate', 'sum', "area", filter:="loc_num"=6 ) / "BGF_locality_area_loc_area"
  when "loc_num" = 7
  then aggregate( 'BGF_flate', 'sum', "area", filter:="loc_num"=7 ) / "BGF_locality_area_loc_area"
  when "loc_num" = 8
  then aggregate( 'BGF_flate', 'sum', "area", filter:="loc_num"=8 ) / "BGF_locality_area_loc_area"
  when "loc_num" = 9
  then aggregate( 'BGF_flate', 'sum', "area", filter:="loc_num"=9 ) / "BGF_locality_area_loc_area"
  when "loc_num" = 10
  then aggregate( 'BGF_flate', 'sum', "area", filter:="loc_num"=10 ) / "BGF_locality_area_loc_area"

  else NULL
END

#### E1
case
  when "2_BG_type" = 'E1' then 0.05
  else NULL
end

#### BGF_final
case
  when "Loc_num" = 1
  then if(aggregate('BGF_flate', 'count_distinct', "E1", filter:= "Loc_num" = 1) = 1, 0.05, null)+
  ("tot_BGF1" + "tot_BGF2") / "BGF_locality_area_loc_area"
  when "Loc_num" = 2
  then if(aggregate('BGF_flate', 'count_distinct', "E1", filter:= "Loc_num" = 2) = 1, 0.05, null)+
  ("tot_BGF1" + "tot_BGF2") / "BGF_locality_area_loc_area"
  when "Loc_num" = 3
  then if(aggregate('BGF_flate', 'count_distinct', "E1", filter:= "Loc_num" = 3) = 1, 0.05, null)+
  ("tot_BGF1" + "tot_BGF2") / "BGF_locality_area_loc_area"
  when "Loc_num" = 4
  then if(aggregate('BGF_flate', 'count_distinct', "E1", filter:= "Loc_num" = 4) = 1, 0.05, null)+
  ("tot_BGF1" + "tot_BGF2") / "BGF_locality_area_loc_area"
  when "Loc_num" = 5
  then if(aggregate('BGF_flate', 'count_distinct', "E1", filter:= "Loc_num" = 5) = 1, 0.05, null)+
  ("tot_BGF1" + "tot_BGF2") / "BGF_locality_area_loc_area"
  when "Loc_num" = 6
  then if(aggregate('BGF_flate', 'count_distinct', "E1", filter:= "Loc_num" = 6) = 1, 0.05, null)+
  ("tot_BGF1" + "tot_BGF2") / "BGF_locality_area_loc_area"
  when "Loc_num" = 7
  then if(aggregate('BGF_flate', 'count_distinct', "E1", filter:= "Loc_num" = 7) = 1, 0.05, null)+
  ("tot_BGF1" + "tot_BGF2") / "BGF_locality_area_loc_area"
  when "Loc_num" = 8
  then if(aggregate('BGF_flate', 'count_distinct', "E1", filter:= "Loc_num" = 8) = 1, 0.05, null)+
  ("tot_BGF1" + "tot_BGF2") / "BGF_locality_area_loc_area"
  when "Loc_num" = 9
  then if(aggregate('BGF_flate', 'count_distinct', "E1", filter:= "Loc_num" = 9) = 1, 0.05, null)+
  ("tot_BGF1" + "tot_BGF2") / "BGF_locality_area_loc_area"
  when "Loc_num" = 10
  then if(aggregate('BGF_flate', 'count_distinct', "E1", filter:= "Loc_num" = 10) = 1, 0.05, null)+
  ("tot_BGF1" + "tot_BGF2") / "BGF_locality_area_loc_area"
END

#### BGF_contrb

if ( "BGF1" is not NULL,
  ("BGF1" / ("tot_BGF1" + "tot_BGF2" )) * 100,
  ("BGF2" / ("tot_BGF1" + "tot_BGF2" )) * 100)

```


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