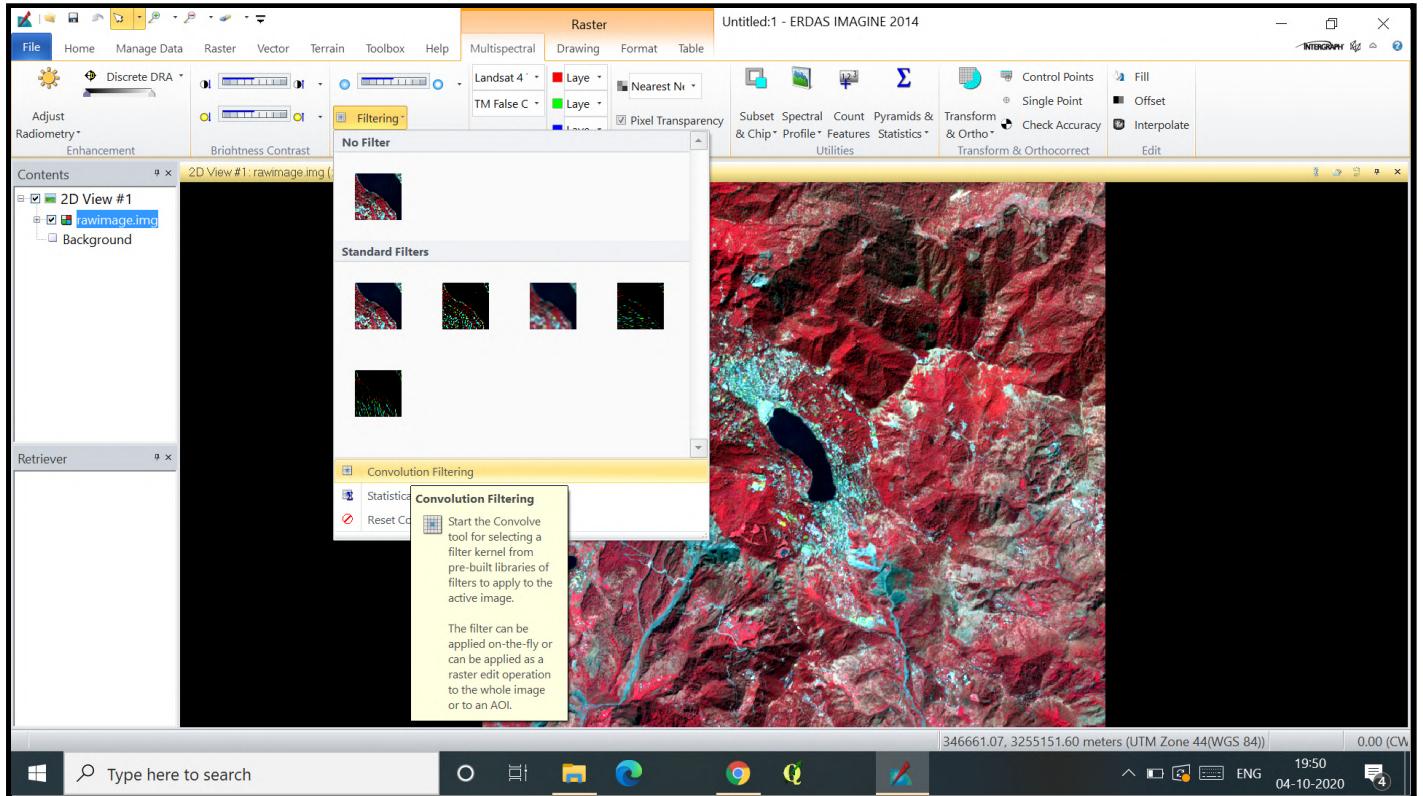


PART-1

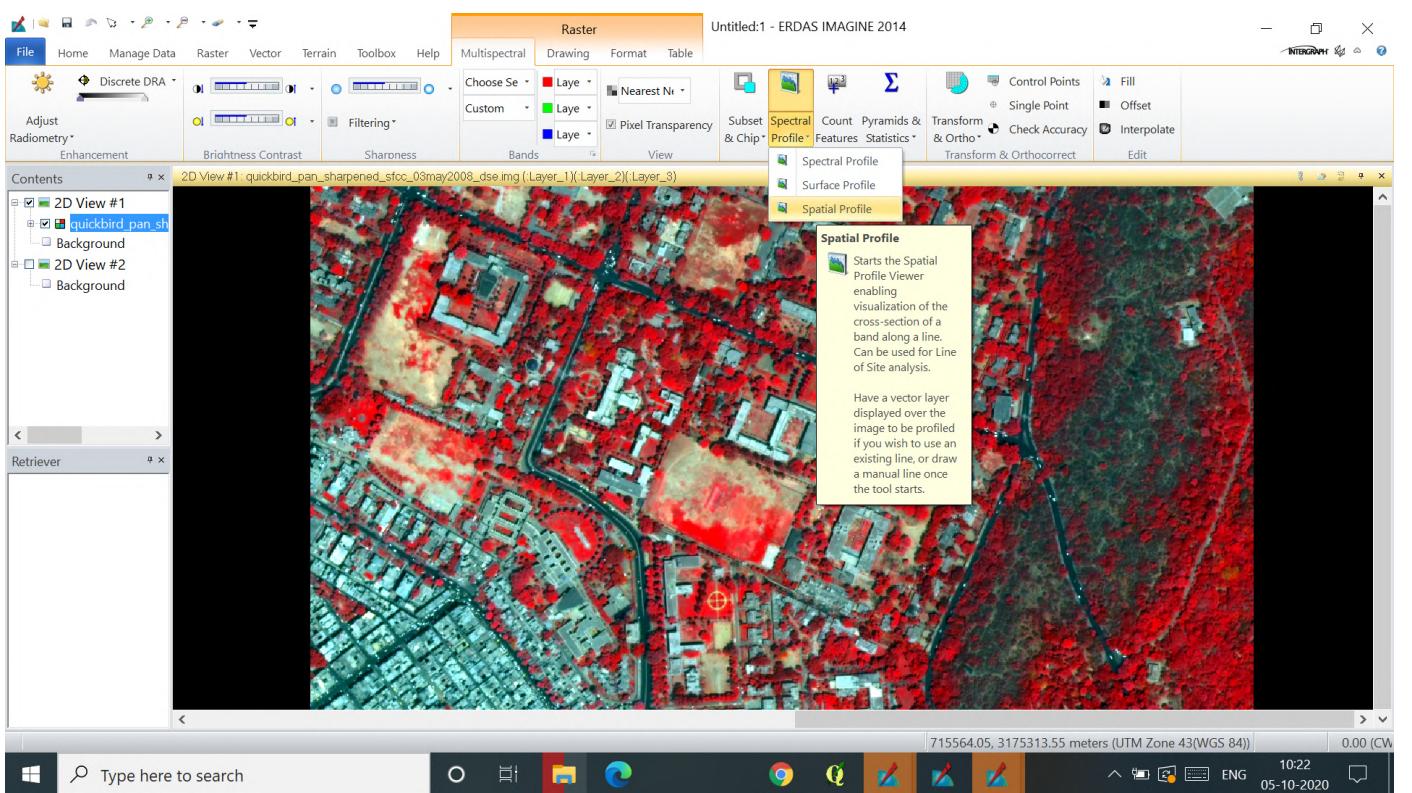
CONVOLUTION FILTER

Step-1 Go to Raster > Multispectral > Filtering > Convolution Filtering

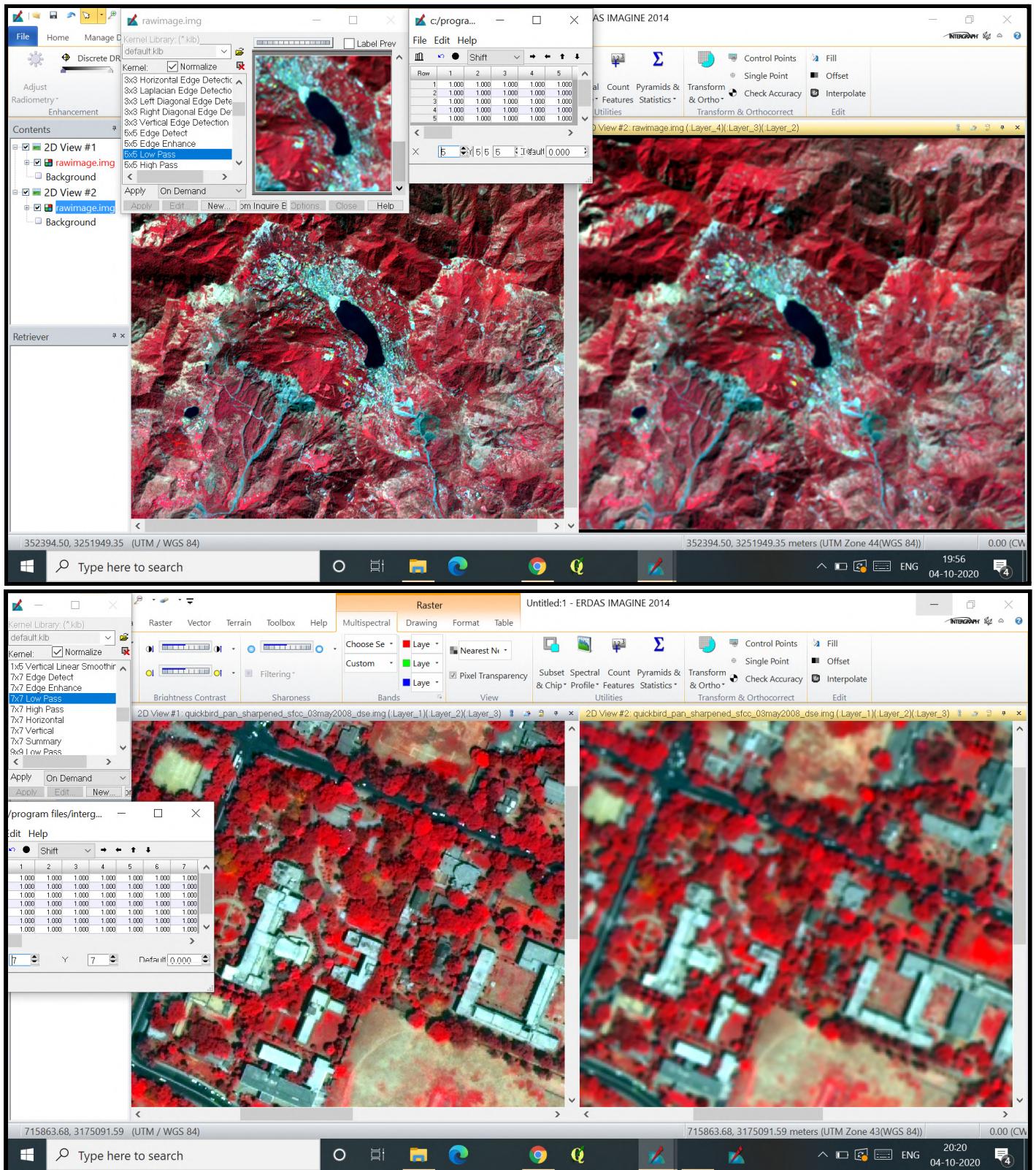


To create spatial Profile

Step-1 Go to Raster > Multispectral > Spectral Profile > Spatial Profile

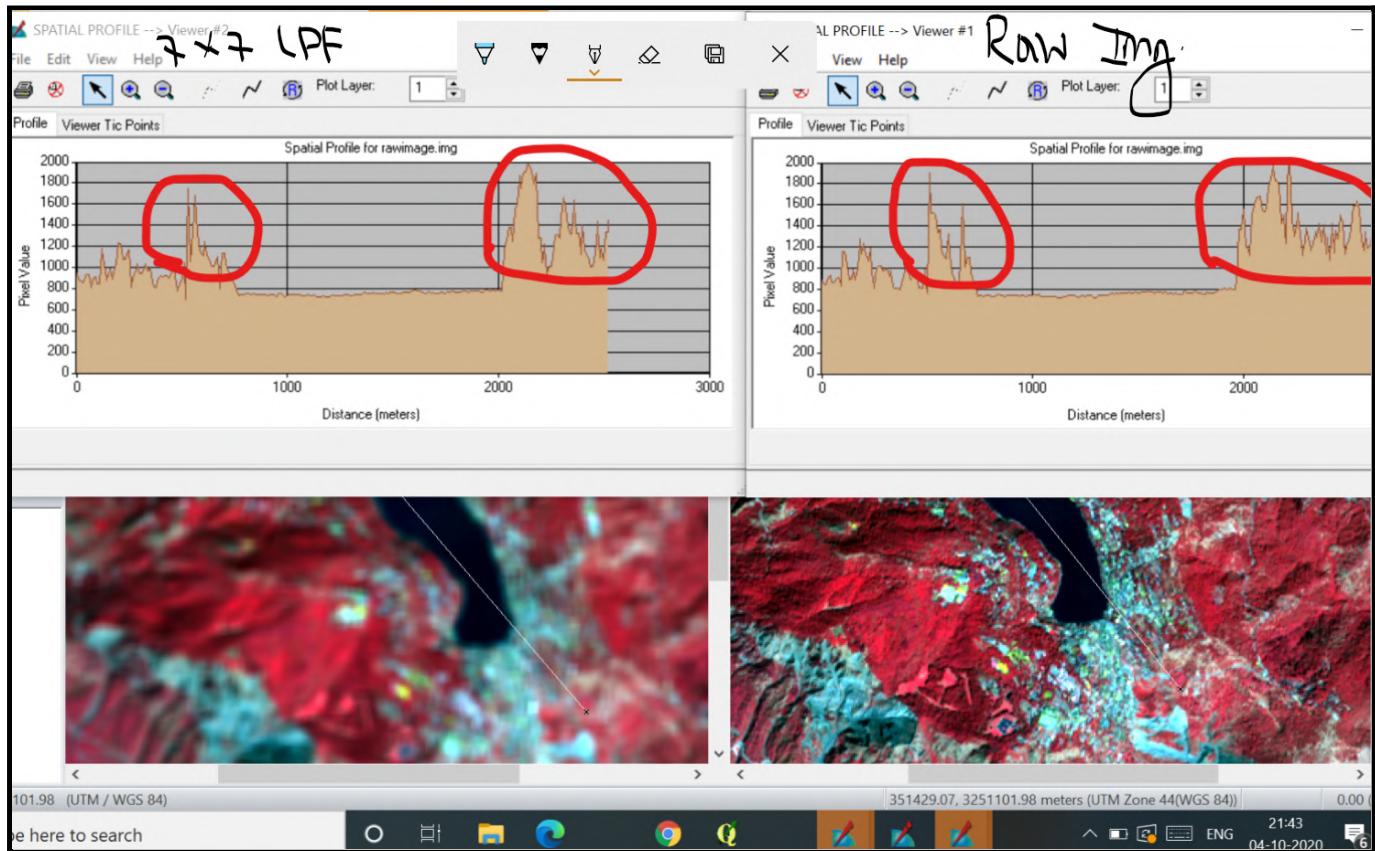


1. Low Pass filter



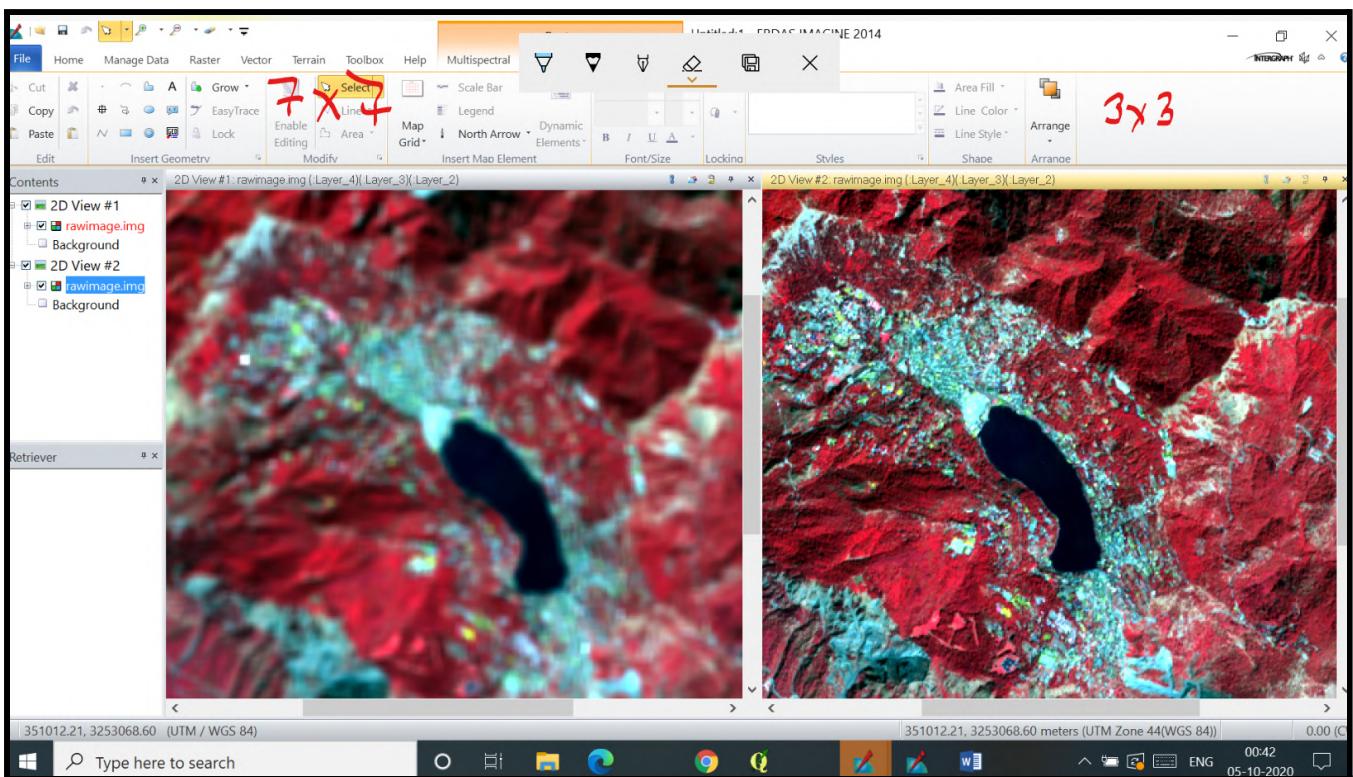
Low Pass filter **blocks or minimizes the high frequency DN values**. This **smoothen** the image (**average filter**) by **blurring** the image especially around the edges of the object and **removes noise** especially **salt and pepper noise**. It emphasizes **regional spatial trends** and de-emphasizes local variability.

Note- In LPF, all the pixels (**Target and Neighbour**) are given the equal weightage as 1 (irrespective of Kernel Size.)



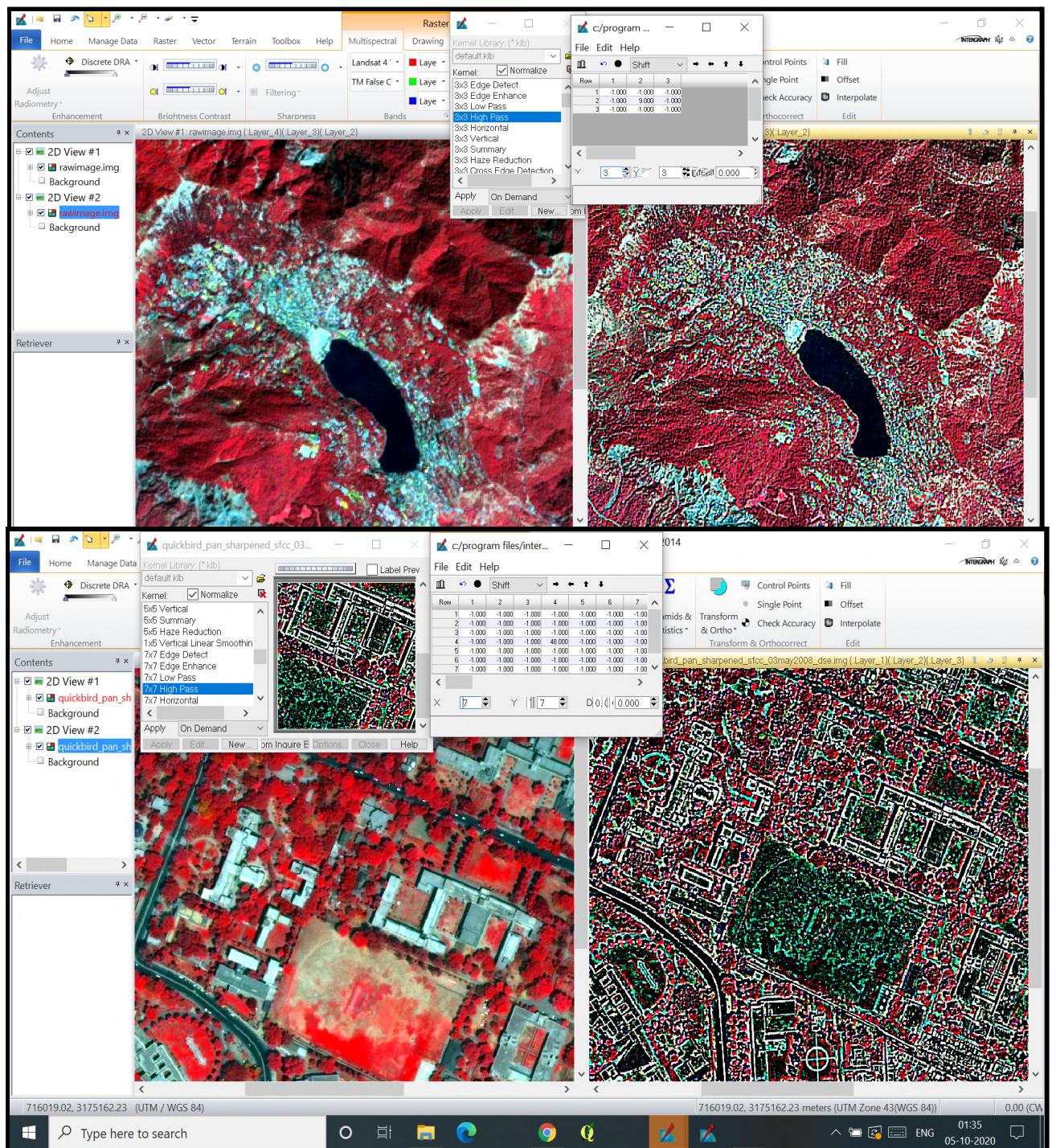
In the **Spatial Profile** it is smoother to some extent, not much but little. However, in the **image smoothness** is clearly visible as there is less local variation.

KERNEL SIZE



Greater than Kernel size in LPF, more effective it is. As blurring becomes more severe as the size of Kernel increases and variations are lessened especially around the edges of the object. and the **image is smoothed. (de- emphasis local variability)**

2. High Pass Filter

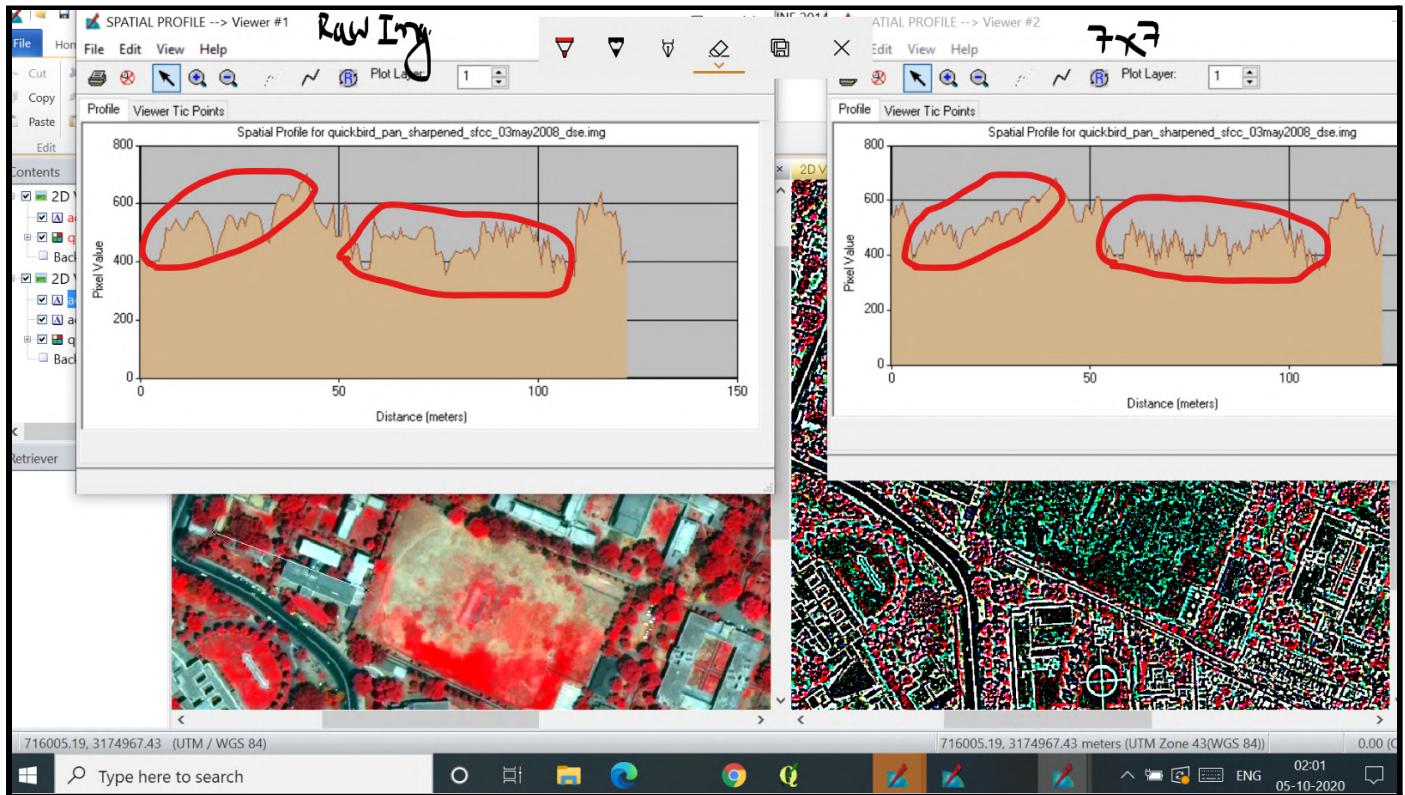


High Pass Filter **preserves high frequencies DN values** and **removes the slowly varying components**. It is precisely the reverse of LPF. It enhances/preserves the **edges and finer details** in images and boundaries can be easily **digitalised**. It enhances overall **sharpness** of image.

Weightage or Multiplier coefficient-- 3*3 HPF-- Target Pixel = +9 ; Neighbourhood Pixel = -1.

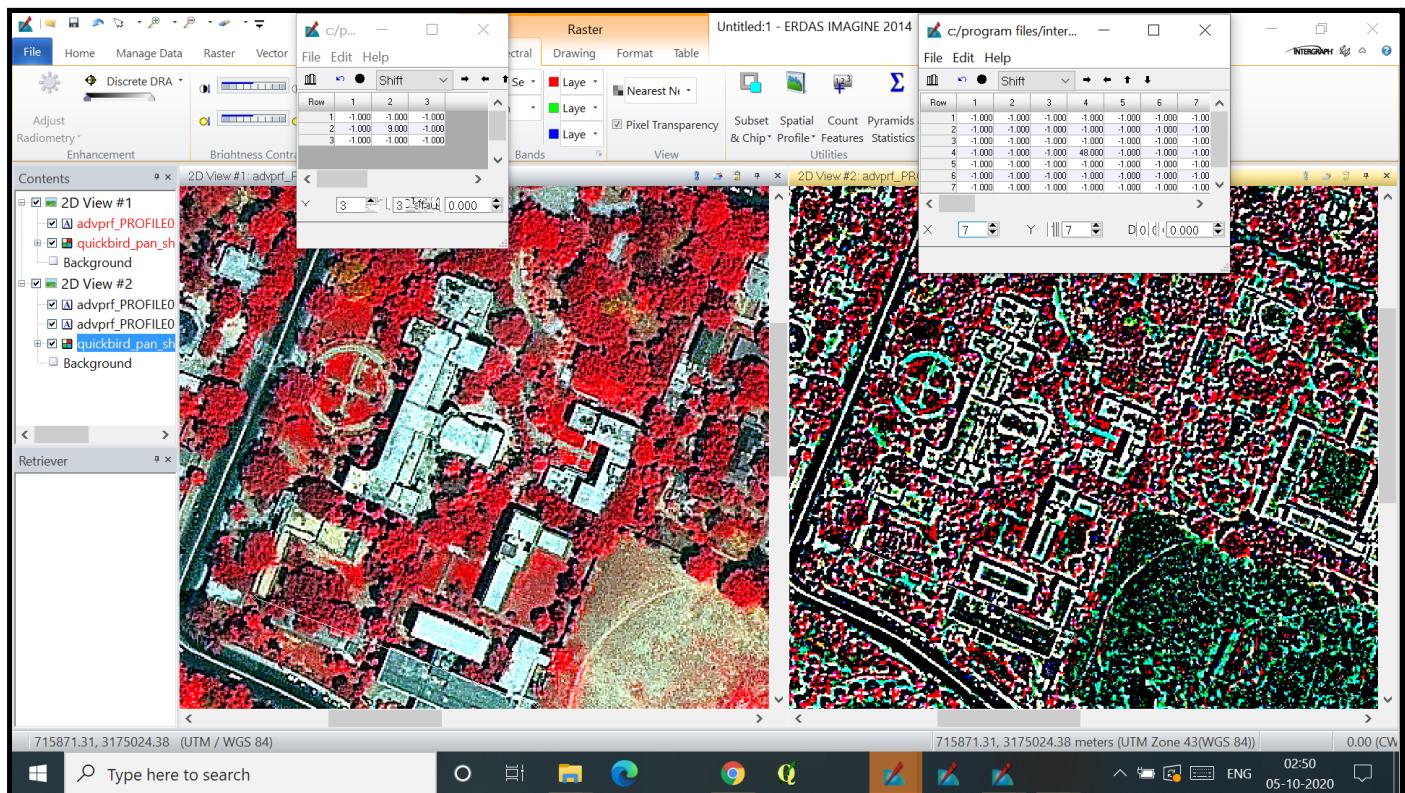
7*7 HPF-- Target Pixel = +48 ; Neighbourhood Pixel = -1.

(Note-Target pixel given more weightage because **performing the function on center value**. In this filter, the sum of positive and negative coefficients cancel out and resultant is 0. i.e. **effectively not adding and subtracting for this particular neighbour**. Thus, one may design their own edge detection filter, only the sum has to be 0.)



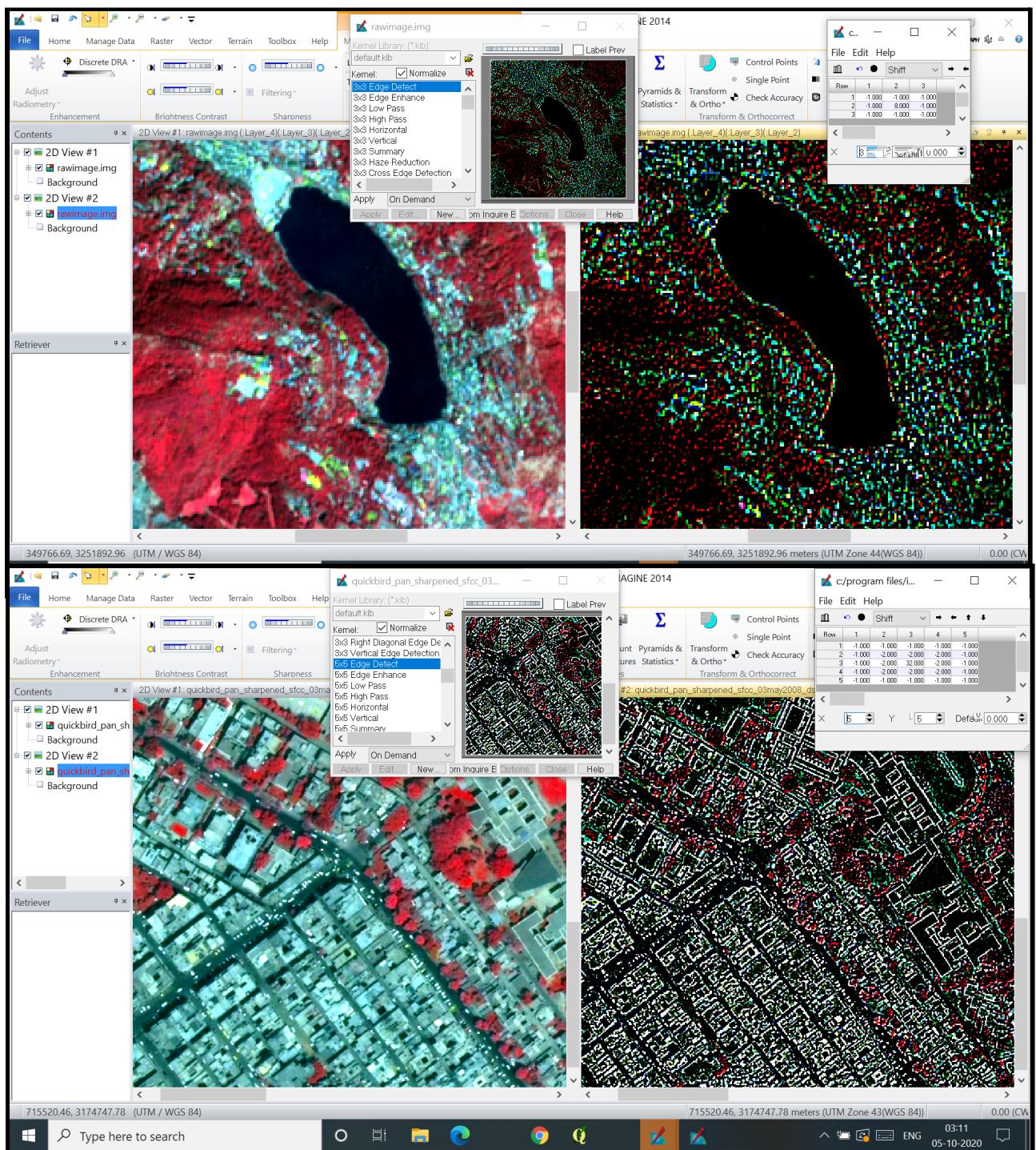
In the **Spatial Profile**, **emphasised local variations** can be seen in **7*7 HPF** which are not there in raw image. It increases the overall sharpen of the image.

KERNEL SIZE



Greater the Kernel size, the more effective it is. As **sharpening** becomes more severe as the size of Kernel increases and **local variations are increased**. The edges are **enhanced** and useful for **digitalization**.

3. Edge Detect



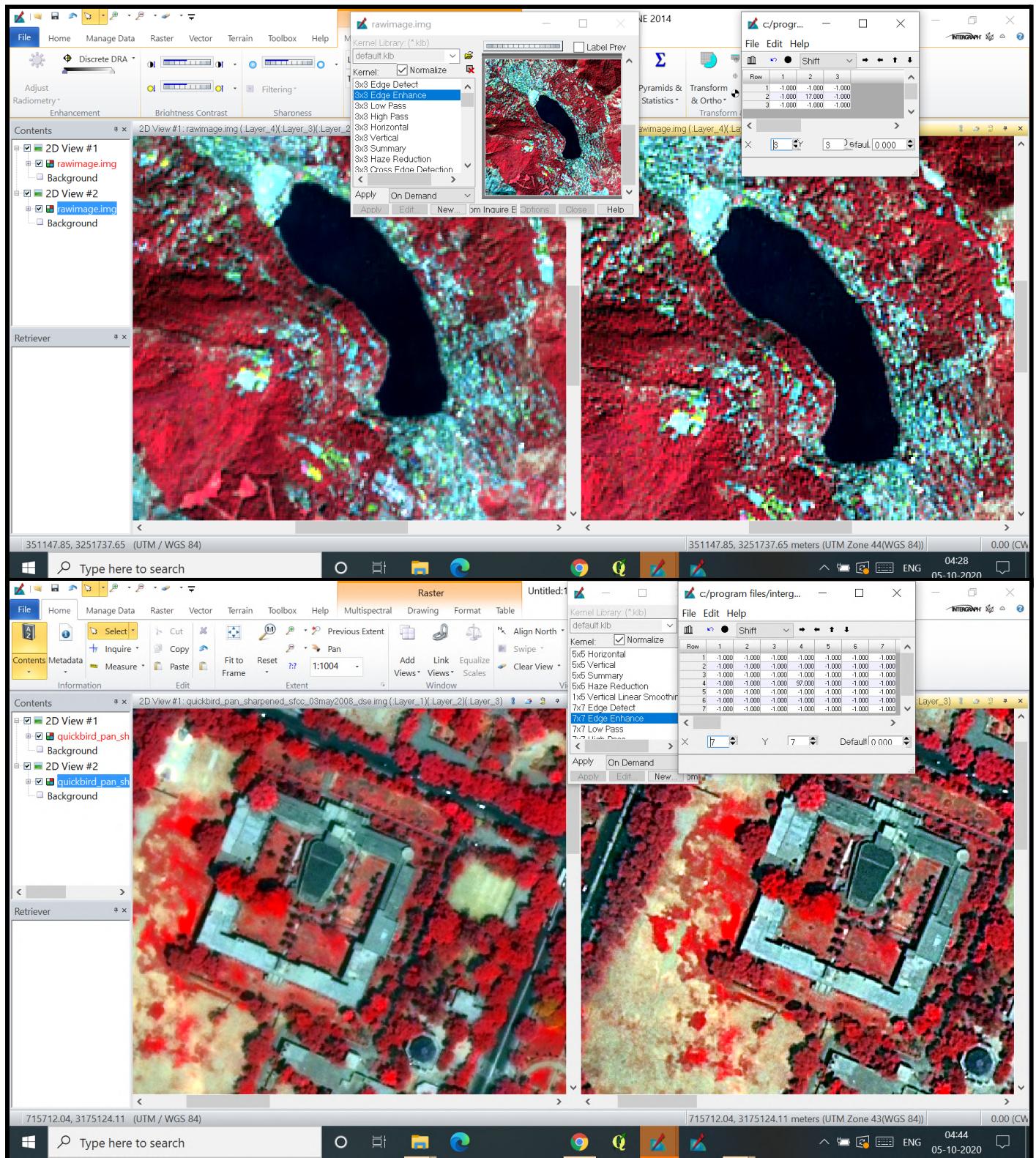
Edges are the boundary where BV values significantly differ among the neighbours. Thus, it is essential to mark boundaries of objects. Edge detection is used to **observe the features** of an image for a significant change in the gray level. It **reduces the amount of data in an image and preserves the structural properties** of an image. In the image, **linear features and building boundaries can be easily identified and digitized**.

Weightage or Multiplier coefficient-- 3*3 ED-- Target Pixel = +8 ; Neighbourhood Pixel = -1.

7*7 ED-- Target Pixel = +32 ; Immediate Neighbourhood Pixel= -2
Neighbourhood Pixel = -1.

Note- In this filter, the sum of positive and negative coefficients cancel out and **resultant is 0 i.e. effectively not adding and subtracting for this particular neighbour**. Thus, one may design their own edge detection filter, only the sum has to be 0.)

4. Edge Enhancement

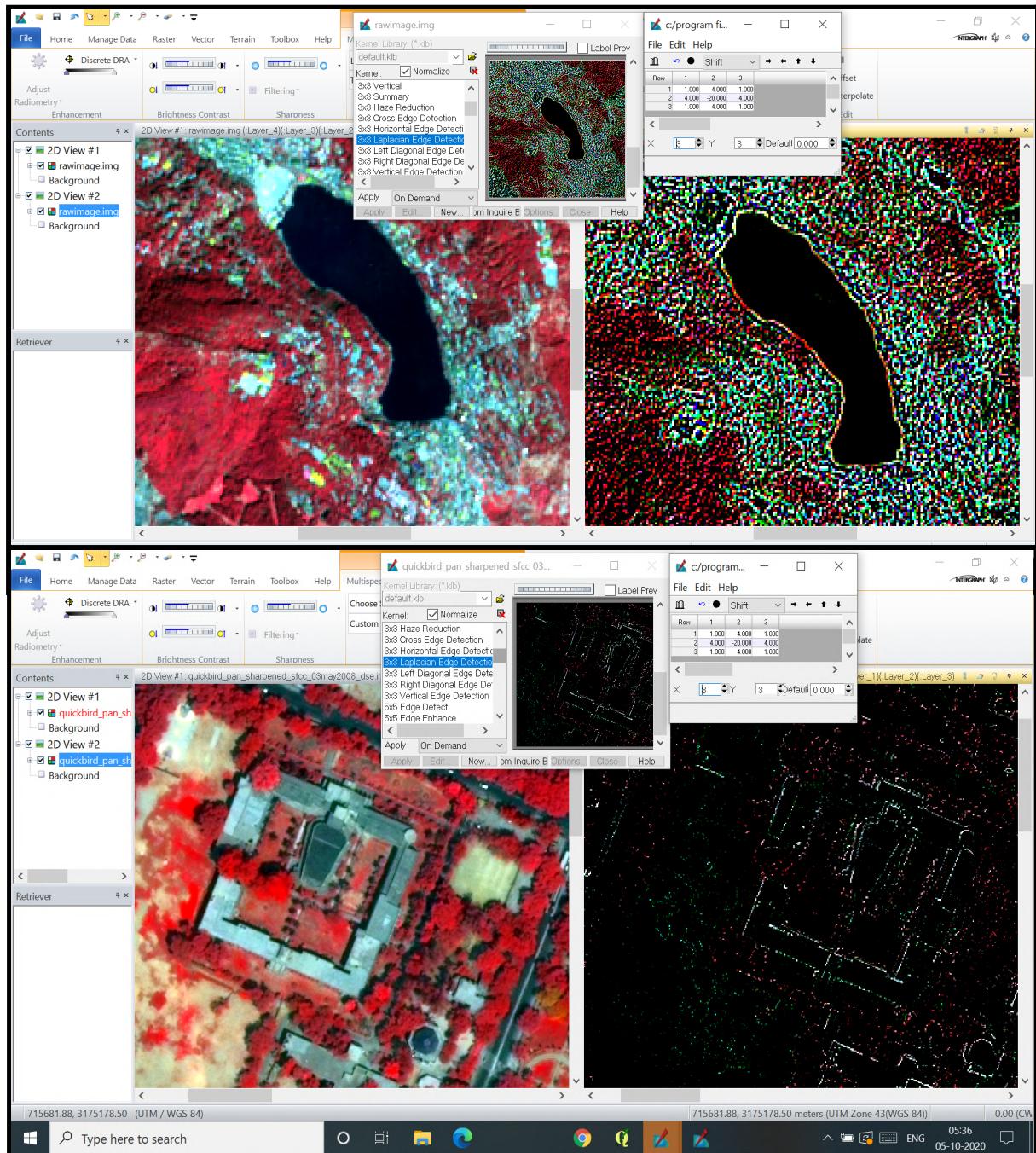


Edge enhancement **delineates the edges** in an image and makes them more **observable and easier to understand**. By applying this filter, the overall **quality** of the image has been enhanced. There are 2 types of edge enhancement - **linear and nonlinear**.

Weightage or Multiplier coefficient-- 3*3 EE-- Target Pixel = +17 ; Neighbourhood Pixel = -1.

7*7 EE-- Target Pixel = +97 ; Neighbourhood Pixel = -1.

5. Laplacian Edge Enhancement

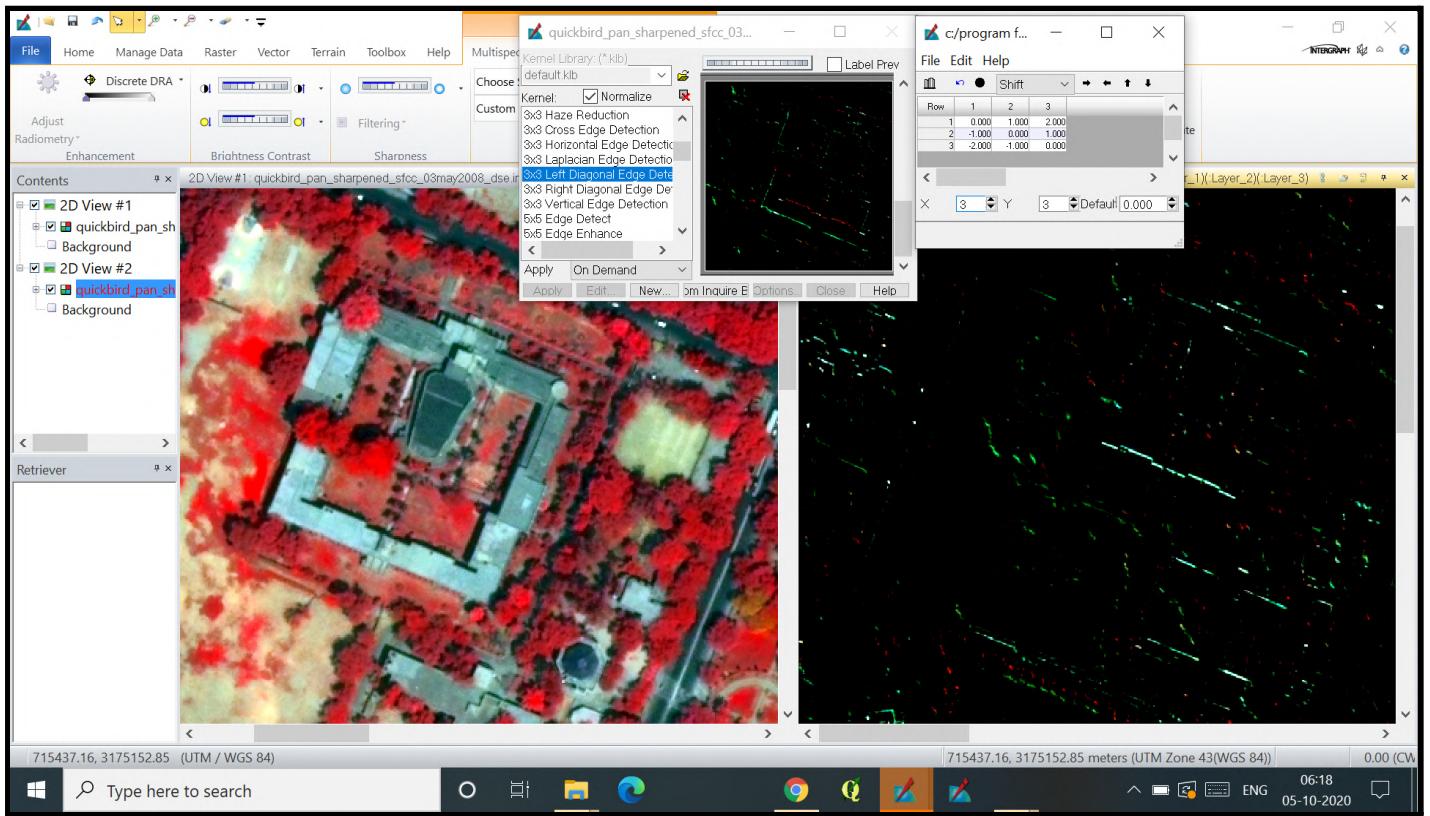


It is a very popular edge operator. It is second derivative along X and Y direction, **isotropic** in nature (can't give directional information). Highlights the region of rapid intensity change. It is **very effective in edge detection**. It generally **highlights the points, lines, edges in an image and suppresses uniform and smoothly varying regions**.

Weightage or Multiplier coefficient-3*3 Laplacian-Target Pixel = -20 ; Immediate Neighbourhood Pixel= +4
Neighbourhood Pixel = +1.

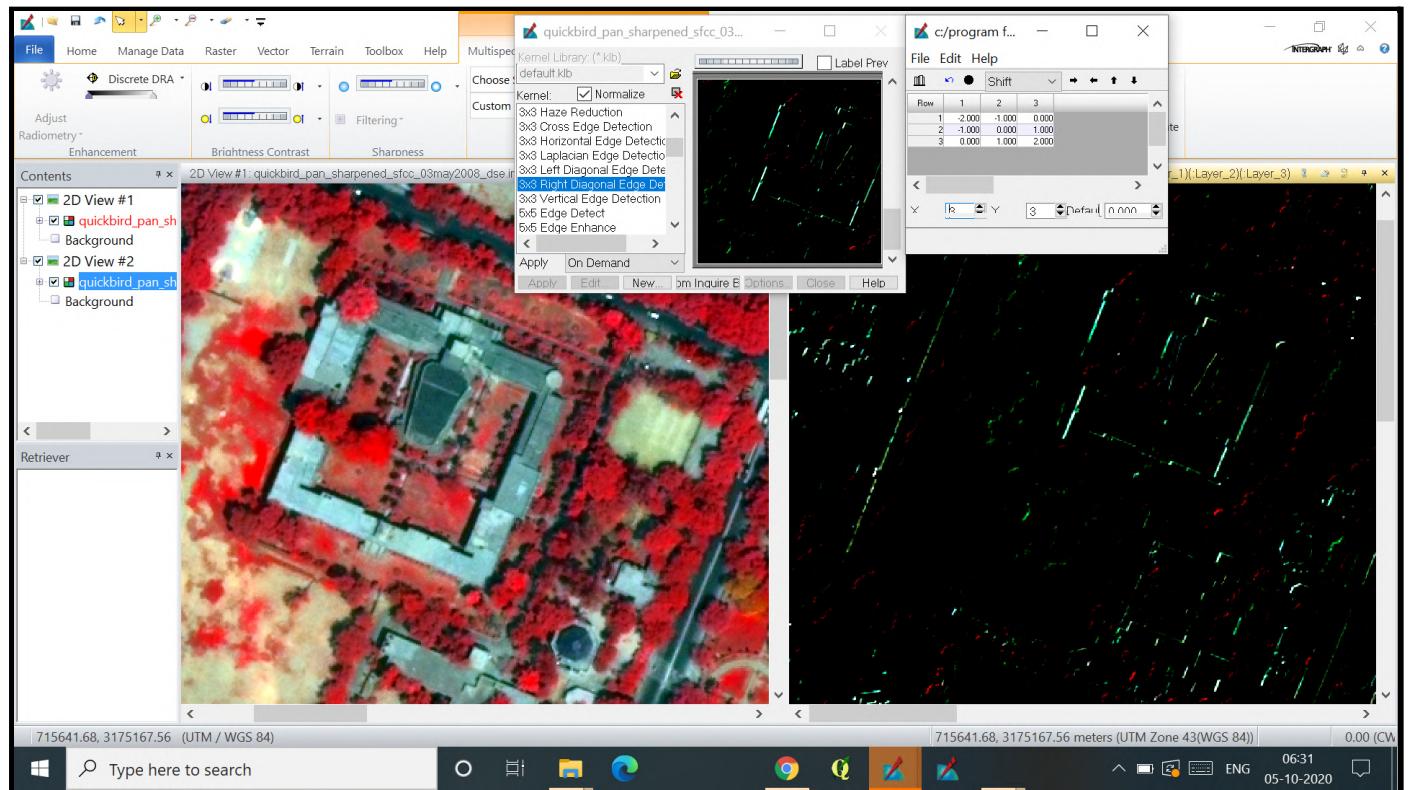
Note- In this filter, the sum of positive and negative coefficients cancel out and **resultant is 0 i.e. effectively not adding and subtracting for this particular neighbour**. Thus, one may design their own Laplacian filter, only the sum has to be 0.)

6. Left Diagonal Edge Detection.



Diagonal edges can be enhanced by computing differences across the diagonal pixels in an image. In Left diagonal edge detection only, the **edges in NW-SE direction are highlighted**.

7. Right Diagonal Edge Detection



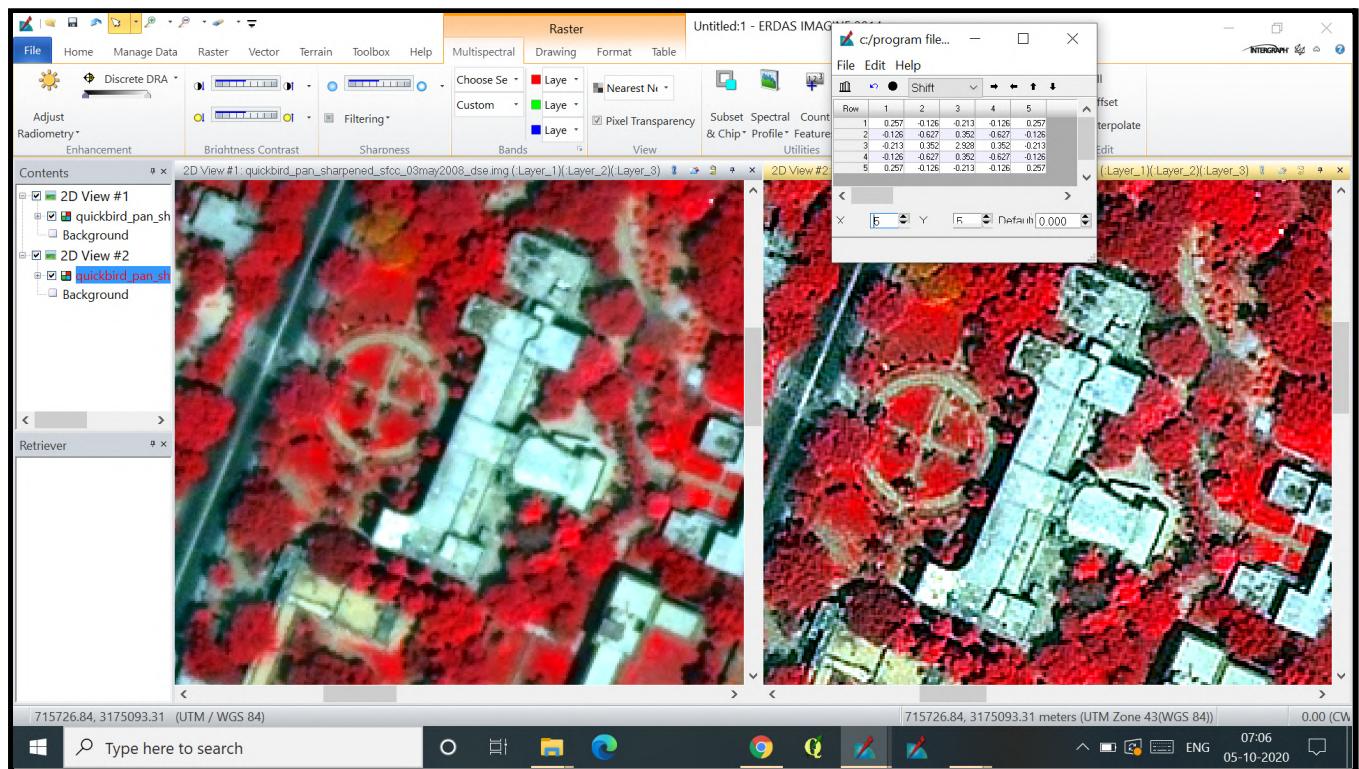
In Right diagonal edge detection only, the **edges in NE-SW direction are highlighted**.

Weightage/ multiplier coefficient

Diagonal orientation	Diagonal value	Above Diagonal Value	Below Diagonal Value	Value 1	Value 2
Left	0	All Positive	All Negative	Immediate neighbour	On the right Diagonal
Right	0	All Negative	All Positive	Immediate neighbour	On the left diagonal

Right and left diagonal are reversed.

8. Haze Reduction



By applying this filter, **haze and smoothness is reduced** and the picture gains overall **rough outlook** and **features are clearer and easier to identify**.

PART-2

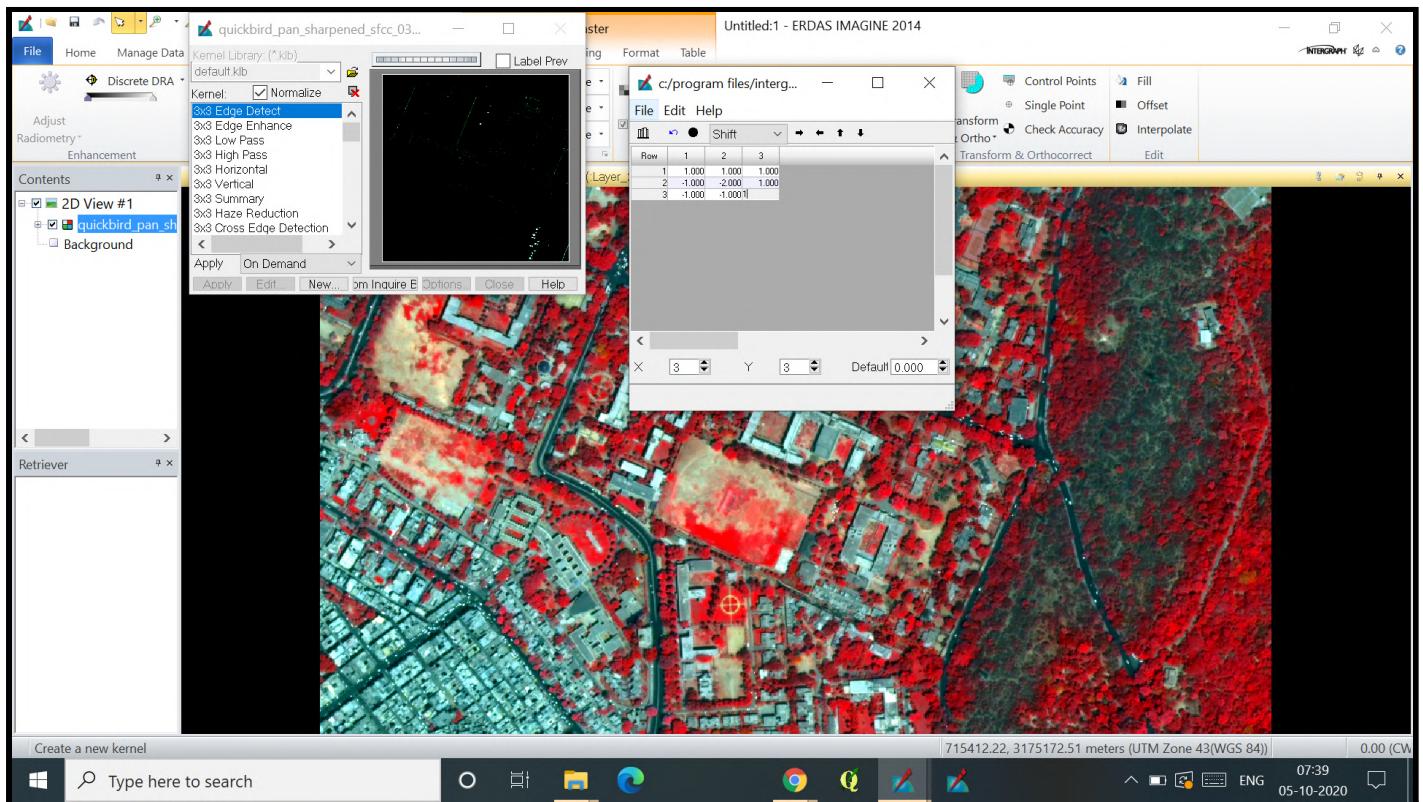
CUSTOMIZED FILTER BY CHANGING KERNEL VALUES.

Convolution mask template = $\begin{bmatrix} c_1 & c_2 & c_3 \\ c_4 & c_5 & c_6 \\ c_7 & c_8 & c_9 \end{bmatrix}$	Example: Low-frequency filter = $\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$																																																																																																																																																																																										
Spatial Filtering	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: center; padding: 2px;">c₁</th><th style="text-align: center; padding: 2px;">c₂</th><th style="text-align: center; padding: 2px;">c₃</th><th style="text-align: center; padding: 2px;">c₄</th><th style="text-align: center; padding: 2px;">c₅</th><th style="text-align: center; padding: 2px;">c₆</th><th style="text-align: center; padding: 2px;">c₇</th><th style="text-align: center; padding: 2px;">c₈</th><th style="text-align: center; padding: 2px;">c₉</th><th style="text-align: center; padding: 2px;">Example</th></tr> </thead> <tbody> <tr> <td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">Figure 8-21b</td></tr> <tr> <td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">-2</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">-2</td><td style="text-align: center; padding: 2px;">5</td><td style="text-align: center; padding: 2px;">-2</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">-2</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">Figure 8-21d</td></tr> </tbody> </table>	c ₁	c ₂	c ₃	c ₄	c ₅	c ₆	c ₇	c ₈	c ₉	Example	1	1	1	1	1	1	1	1	1	Figure 8-21b	1	-2	1	-2	5	-2	1	-2	1	Figure 8-21d																																																																																																																																																												
c ₁	c ₂	c ₃	c ₄	c ₅	c ₆	c ₇	c ₈	c ₉	Example																																																																																																																																																																																		
1	1	1	1	1	1	1	1	1	Figure 8-21b																																																																																																																																																																																		
1	-2	1	-2	5	-2	1	-2	1	Figure 8-21d																																																																																																																																																																																		
Linear Edge Enhancement	<table border="1" style="width: 100%; border-collapse: collapse;"> <tbody> <tr> <td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">Figure 8-22a</td></tr> <tr> <td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">---</td></tr> <tr> <td style="text-align: center; padding: 2px;">-0.7</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">-0.7</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">6.8</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">-0.7</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">-0.7</td><td style="text-align: center; padding: 2px;">---</td></tr> <tr> <td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">-2</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">---</td></tr> <tr> <td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">-2</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">Figure 8-22b</td></tr> <tr> <td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">-2</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">---</td></tr> <tr> <td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">-2</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">---</td></tr> <tr> <td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">-2</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">---</td></tr> <tr> <td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">-2</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">---</td></tr> <tr> <td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">-2</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">---</td></tr> <tr> <td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">-2</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">---</td></tr> <tr> <td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">---</td></tr> <tr> <td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">---</td></tr> <tr> <td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">---</td></tr> <tr> <td style="text-align: center; padding: 2px;">Nonlinear Edge Enhancement</td><td style="text-align: center; padding: 10px;"></td></tr> <tr> <td style="text-align: center; padding: 2px;">Laplacian 4</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">4</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">Figure 8-22c</td></tr> <tr> <td style="text-align: center; padding: 2px;">Laplacian 5</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">5</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">0</td><td style="text-align: center; padding: 2px;">Figure 8-22d</td></tr> <tr> <td style="text-align: center; padding: 2px;">Laplacian 7</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">-7</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">1</td><td style="text-align: center; padding: 2px;">---</td></tr> <tr> <td style="text-align: center; padding: 2px;">Laplacian 8</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">8</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">-1</td><td style="text-align: center; padding: 2px;">---</td></tr> </tbody> </table>	0	0	1	0	0	0	-1	0	0	Figure 8-22a	0	0	0	1	0	-1	0	0	0	---	-0.7	-1	-0.7	-1	6.8	-1	-0.7	-1	-0.7	---	1	1	1	1	-2	1	-1	-1	-1	---	1	1	1	-1	-2	1	-1	-1	1	Figure 8-22b	-1	1	1	-1	-2	1	-1	1	1	---	-1	-1	1	-1	-2	1	1	1	1	---	-1	-1	-1	1	-2	1	1	1	1	---	1	-1	-1	1	-2	-1	1	1	1	---	1	1	-1	1	-2	-1	1	1	-1	---	1	1	1	1	-2	-1	1	-1	-1	---	-1	0	1	-1	0	1	-1	0	1	---	-1	-1	-1	0	0	0	1	1	1	---	0	1	1	-1	0	1	-1	-1	0	---	Nonlinear Edge Enhancement		Laplacian 4	0	-1	0	-1	4	-1	0	-1	0	Figure 8-22c	Laplacian 5	0	-1	0	-1	5	-1	0	-1	0	Figure 8-22d	Laplacian 7	1	1	1	1	-7	1	1	1	1	---	Laplacian 8	-1	-1	-1	-1	8	-1	-1	-1	-1	---
0	0	1	0	0	0	-1	0	0	Figure 8-22a																																																																																																																																																																																		
0	0	0	1	0	-1	0	0	0	---																																																																																																																																																																																		
-0.7	-1	-0.7	-1	6.8	-1	-0.7	-1	-0.7	---																																																																																																																																																																																		
1	1	1	1	-2	1	-1	-1	-1	---																																																																																																																																																																																		
1	1	1	-1	-2	1	-1	-1	1	Figure 8-22b																																																																																																																																																																																		
-1	1	1	-1	-2	1	-1	1	1	---																																																																																																																																																																																		
-1	-1	1	-1	-2	1	1	1	1	---																																																																																																																																																																																		
-1	-1	-1	1	-2	1	1	1	1	---																																																																																																																																																																																		
1	-1	-1	1	-2	-1	1	1	1	---																																																																																																																																																																																		
1	1	-1	1	-2	-1	1	1	-1	---																																																																																																																																																																																		
1	1	1	1	-2	-1	1	-1	-1	---																																																																																																																																																																																		
-1	0	1	-1	0	1	-1	0	1	---																																																																																																																																																																																		
-1	-1	-1	0	0	0	1	1	1	---																																																																																																																																																																																		
0	1	1	-1	0	1	-1	-1	0	---																																																																																																																																																																																		
Nonlinear Edge Enhancement																																																																																																																																																																																											
Laplacian 4	0	-1	0	-1	4	-1	0	-1	0	Figure 8-22c																																																																																																																																																																																	
Laplacian 5	0	-1	0	-1	5	-1	0	-1	0	Figure 8-22d																																																																																																																																																																																	
Laplacian 7	1	1	1	1	-7	1	1	1	1	---																																																																																																																																																																																	
Laplacian 8	-1	-1	-1	-1	8	-1	-1	-1	-1	---																																																																																																																																																																																	

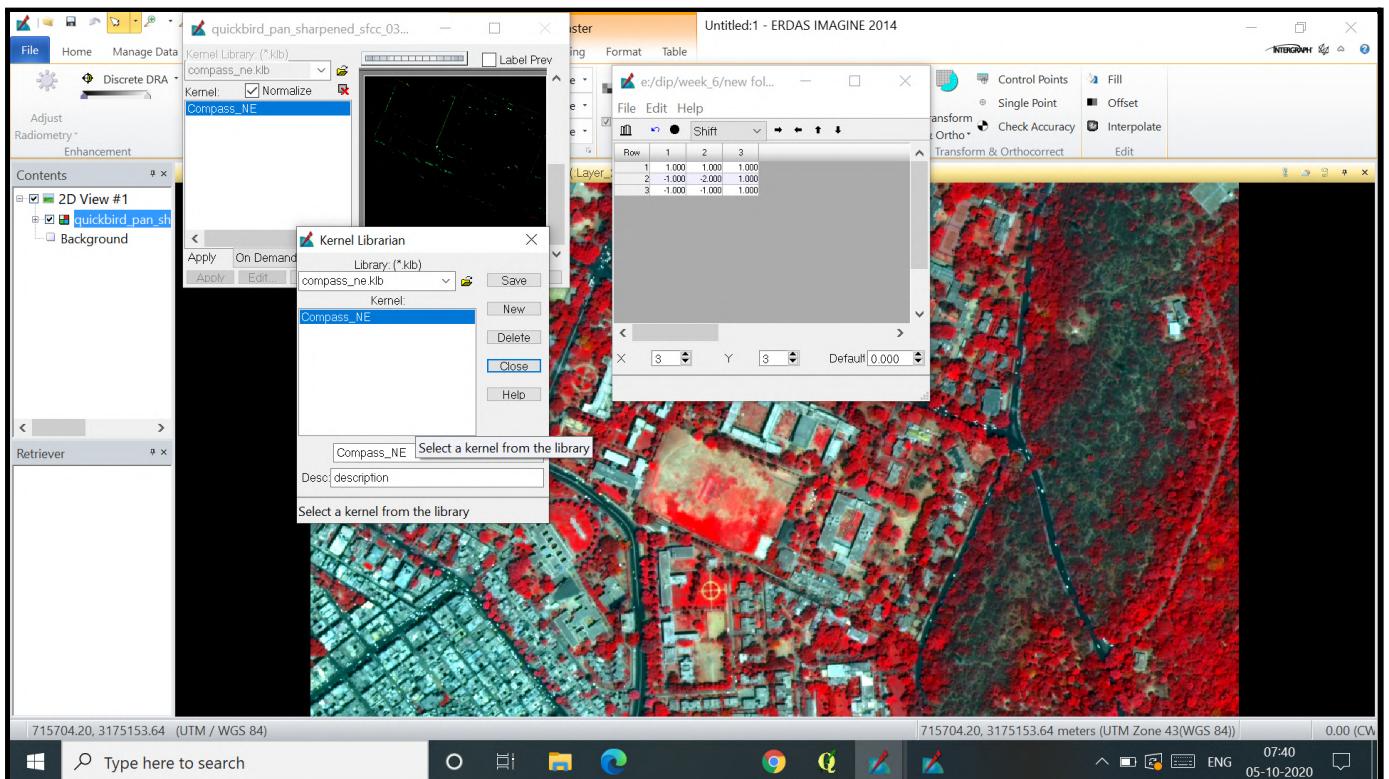
Steps to Create new library

Step-1 Go to Raster > Multispectral > Convolution Filtering

Step-2 Go to New (To make new Kernel) make the desired design.

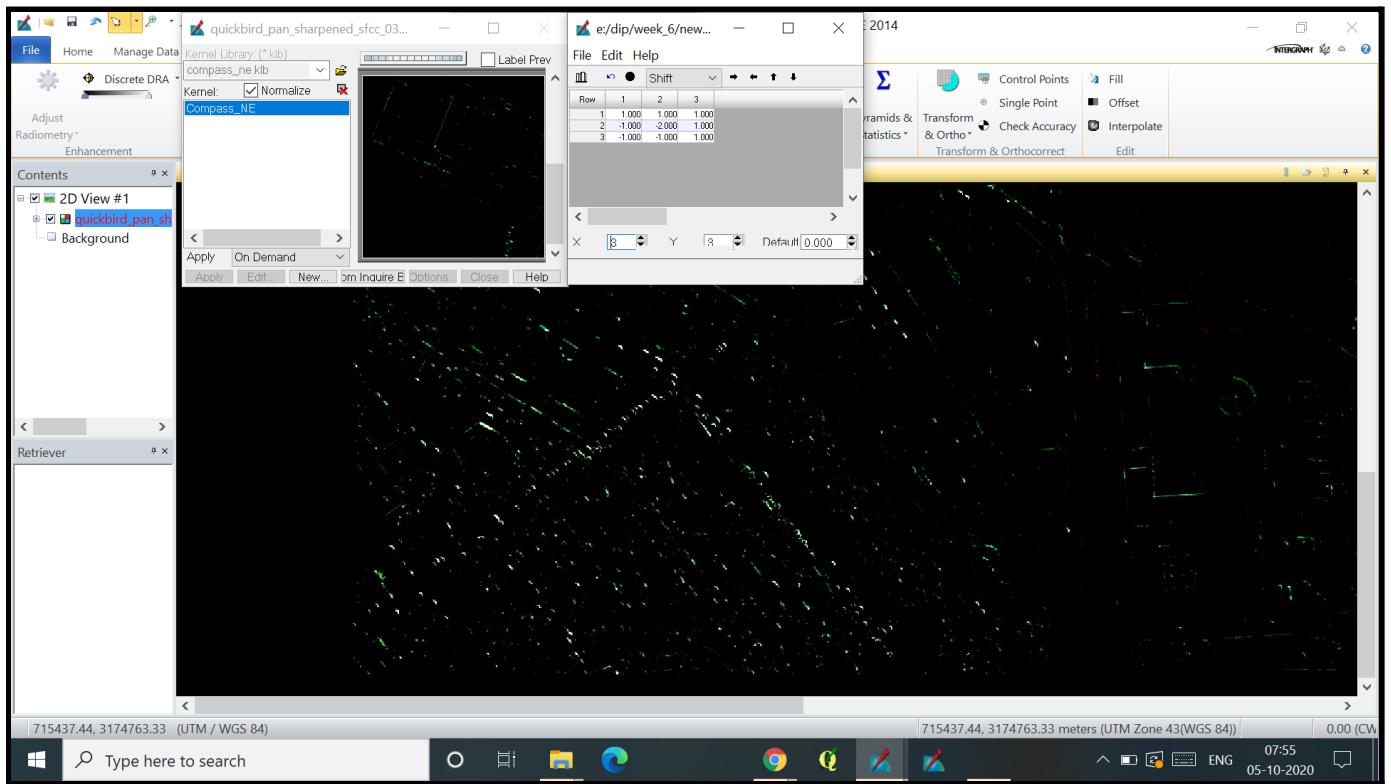


Step-3 Go to File > Librarian > browse the folder and save it. Click OK. Give the **filter name** and save.



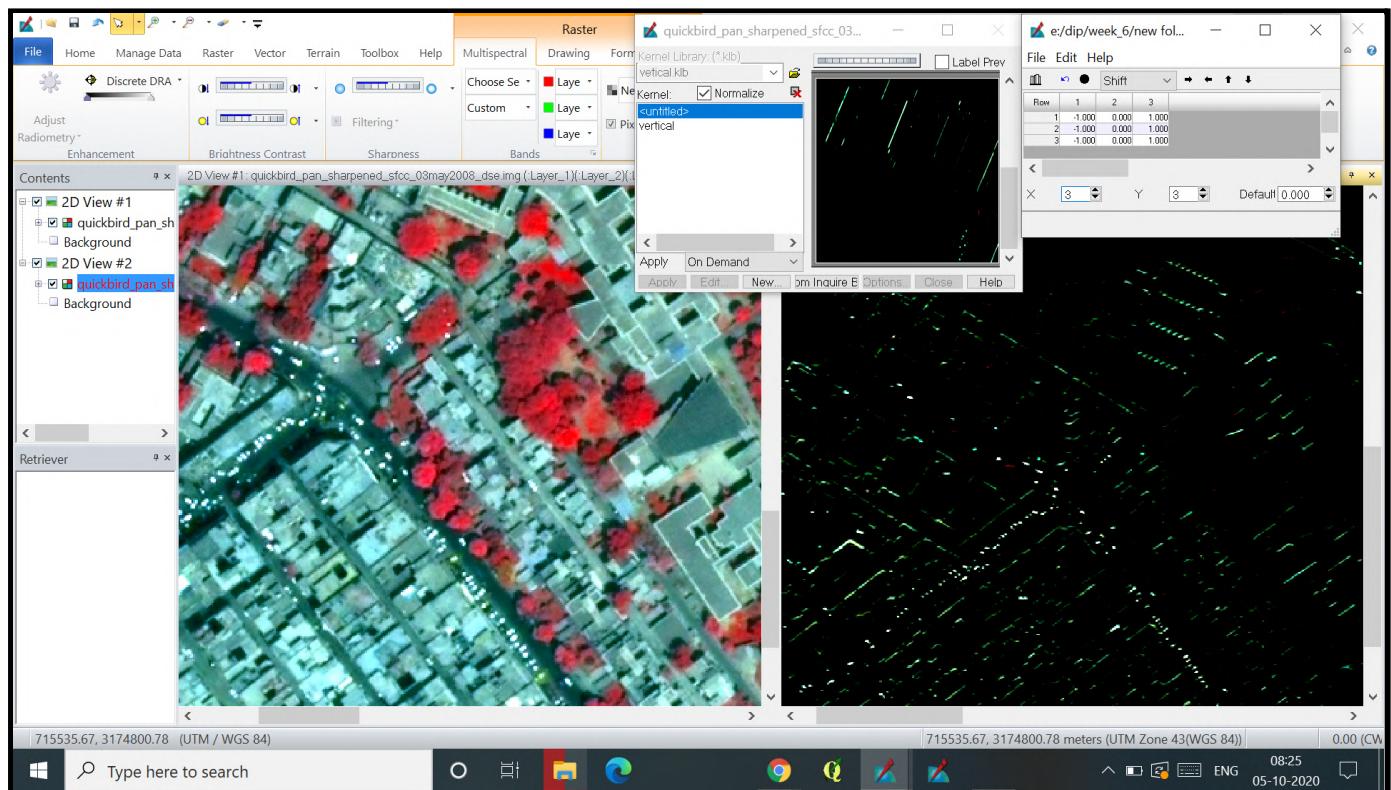
Reload the raw image and apply the filter.

1. Compass NE



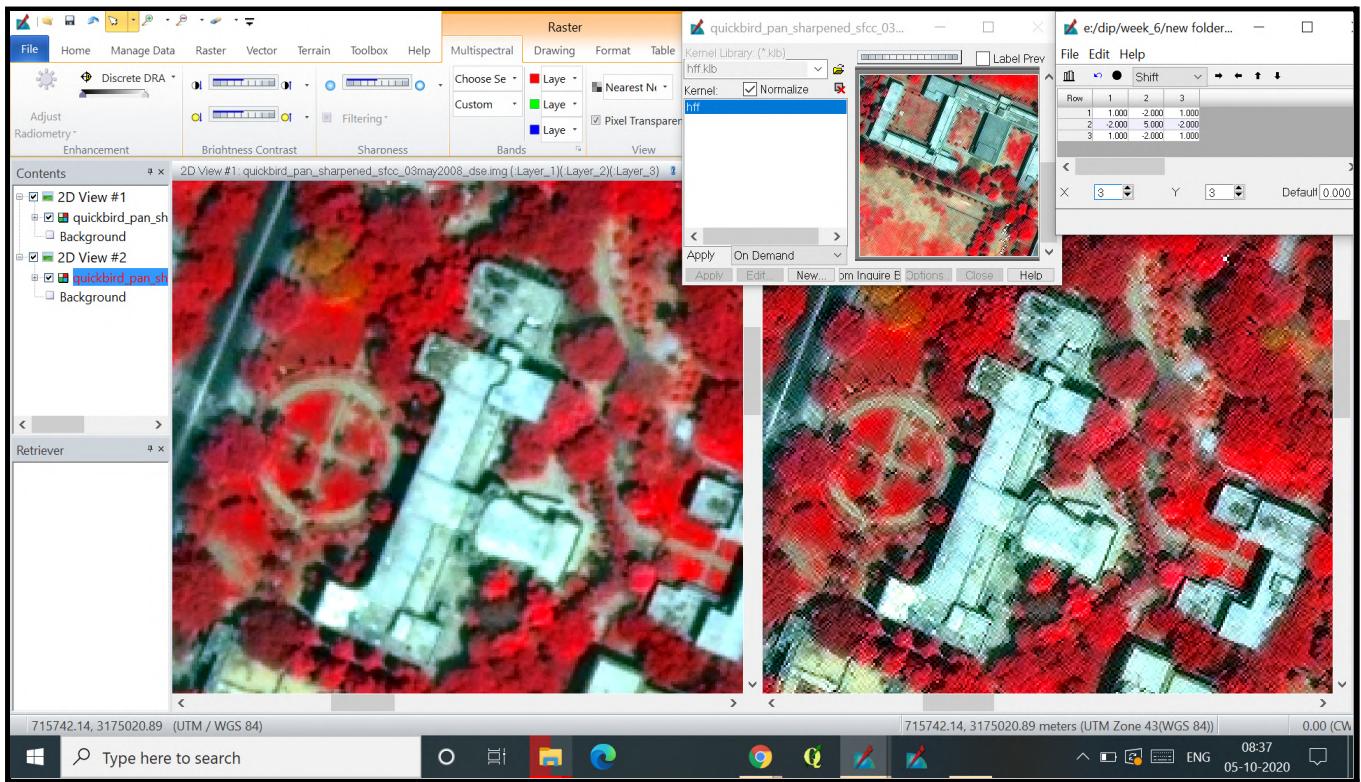
This filter performs **two- dimensional, discrete differential directional edge enhancement**. The compass name suggests **the slope direction of maximum response**. In this case, it is in NE direction.

2. Vertical Edges



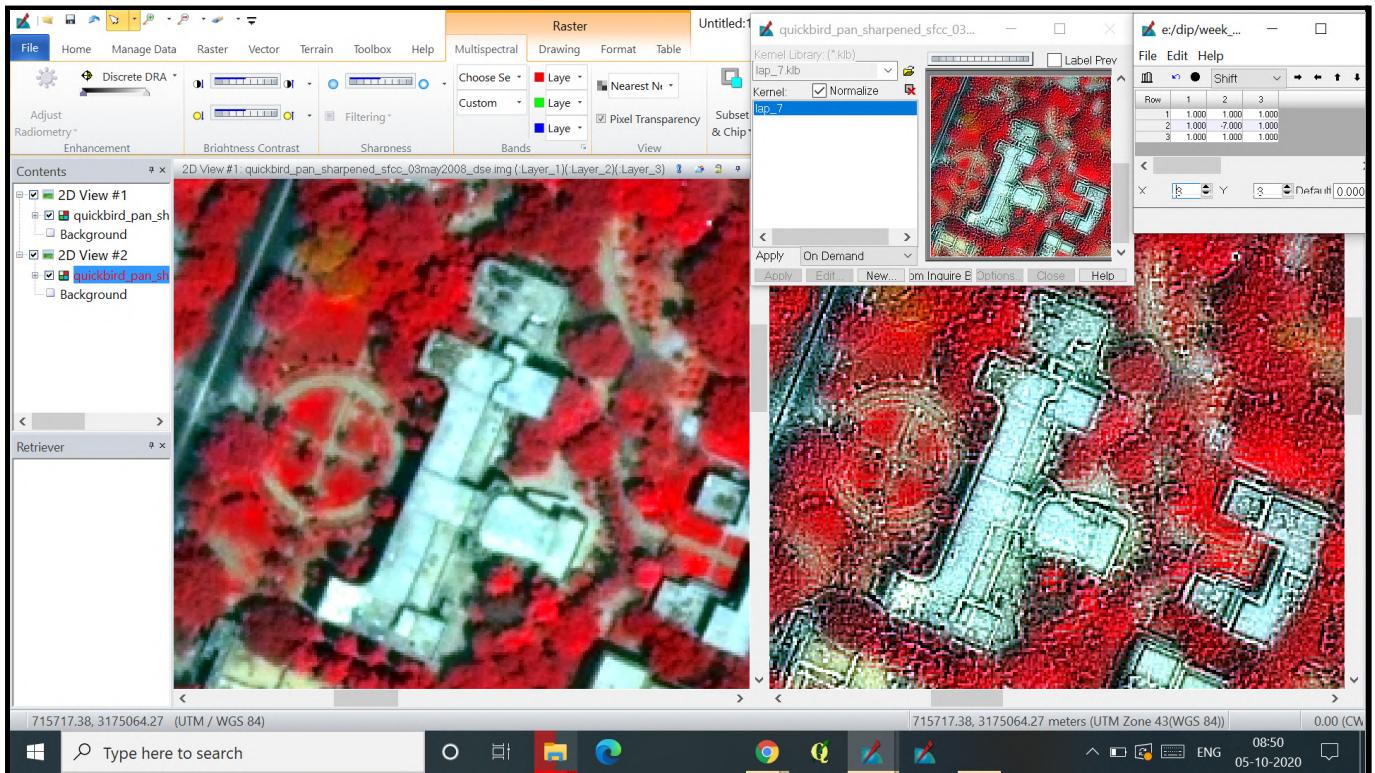
In this case, the **vertical edges are highlighted**.

3. High Frequency (HFF)



This filter blocks the low frequencies and enhances high frequency local variations. The smoothness from raw image is removed and the **sharpness has increased along the edges**.

4. Laplacian-7



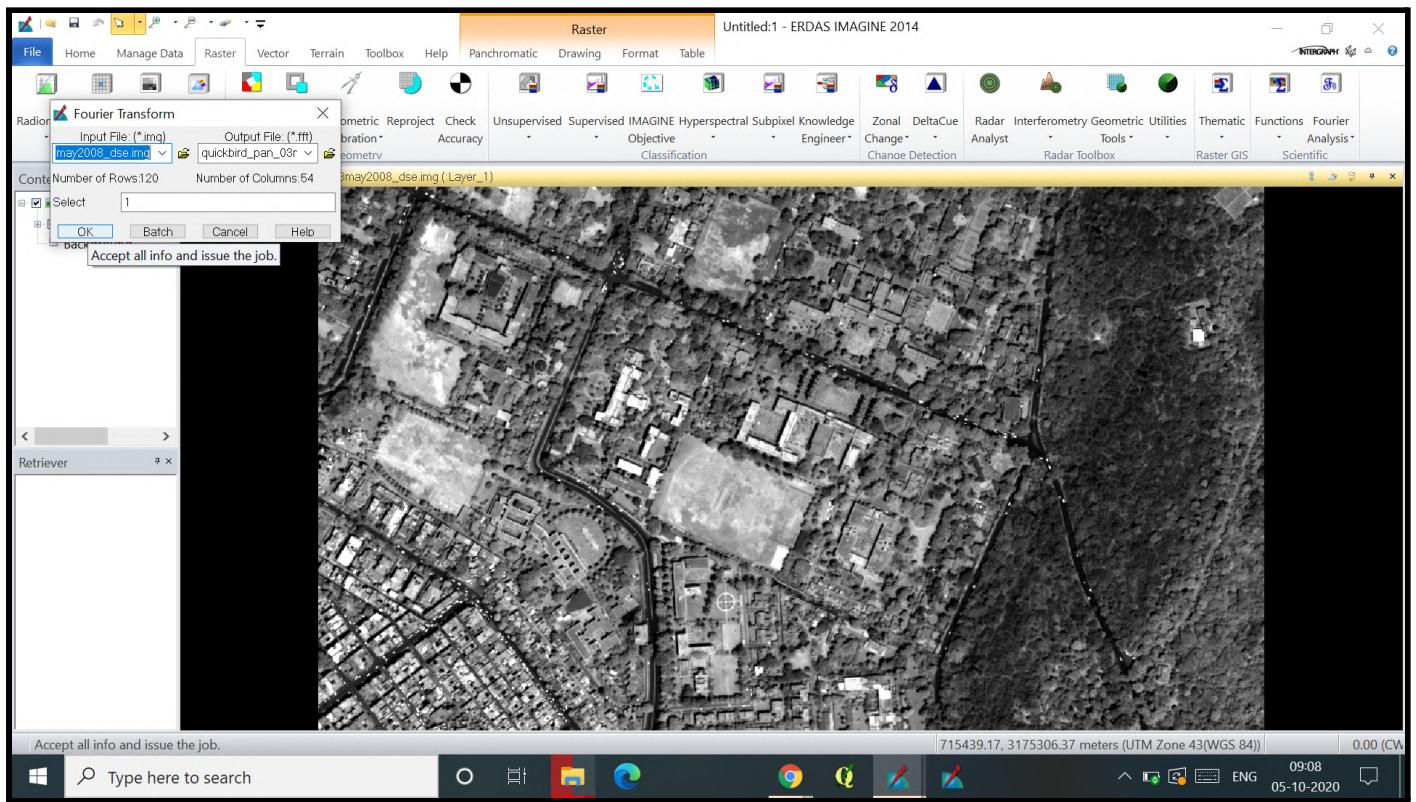
It is used to **enhance the edges**. It also sharpens the image by locally increasing the contrast at discontinuities.

PART-3

FOURIER TRANSFORM

Step-1 Go to **Raster > Fourier Analysis > Fourier Transform**

Give the output file name and click OK.



Step-2 Go to **Fourier Transform Editor**. Editor will open. Then Go to **File > Open > open fft image**

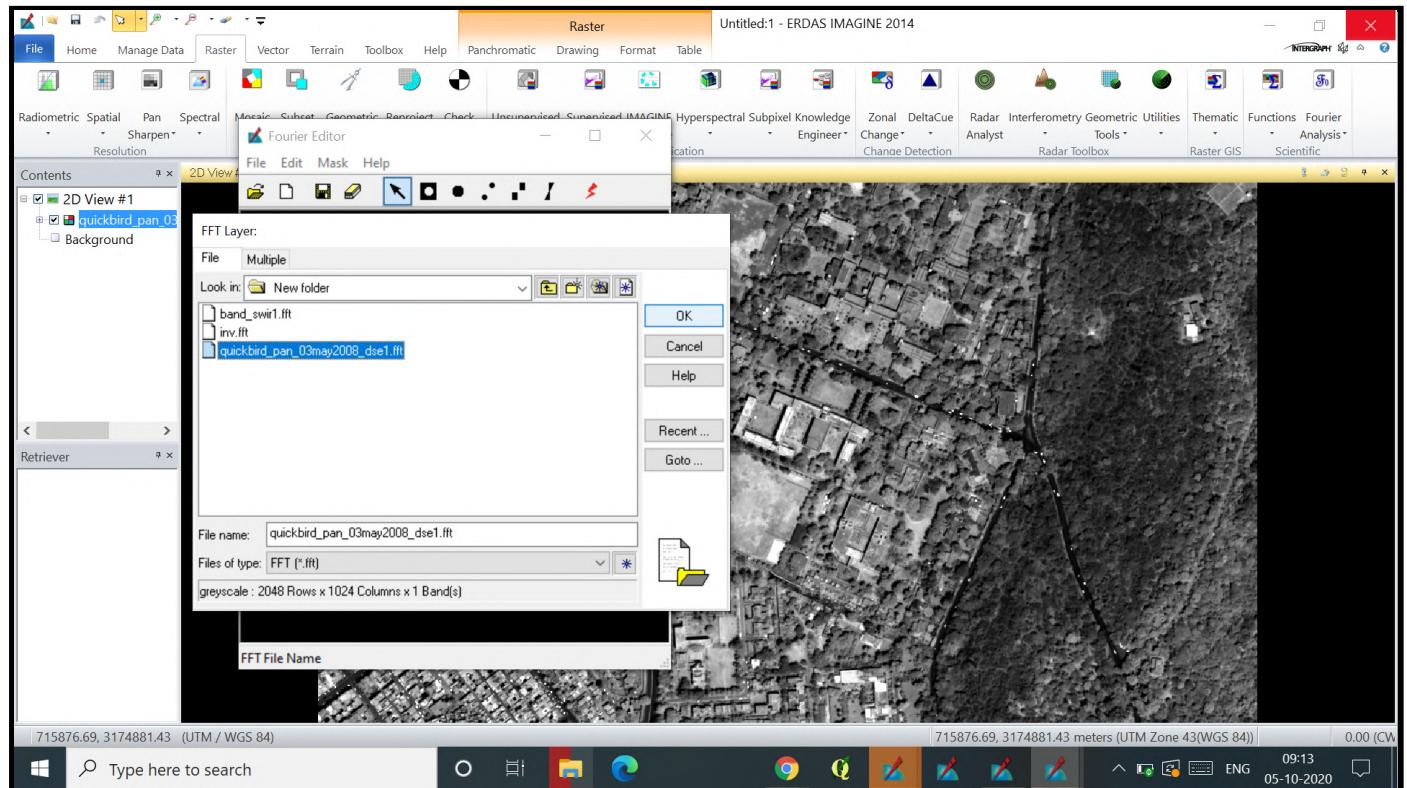
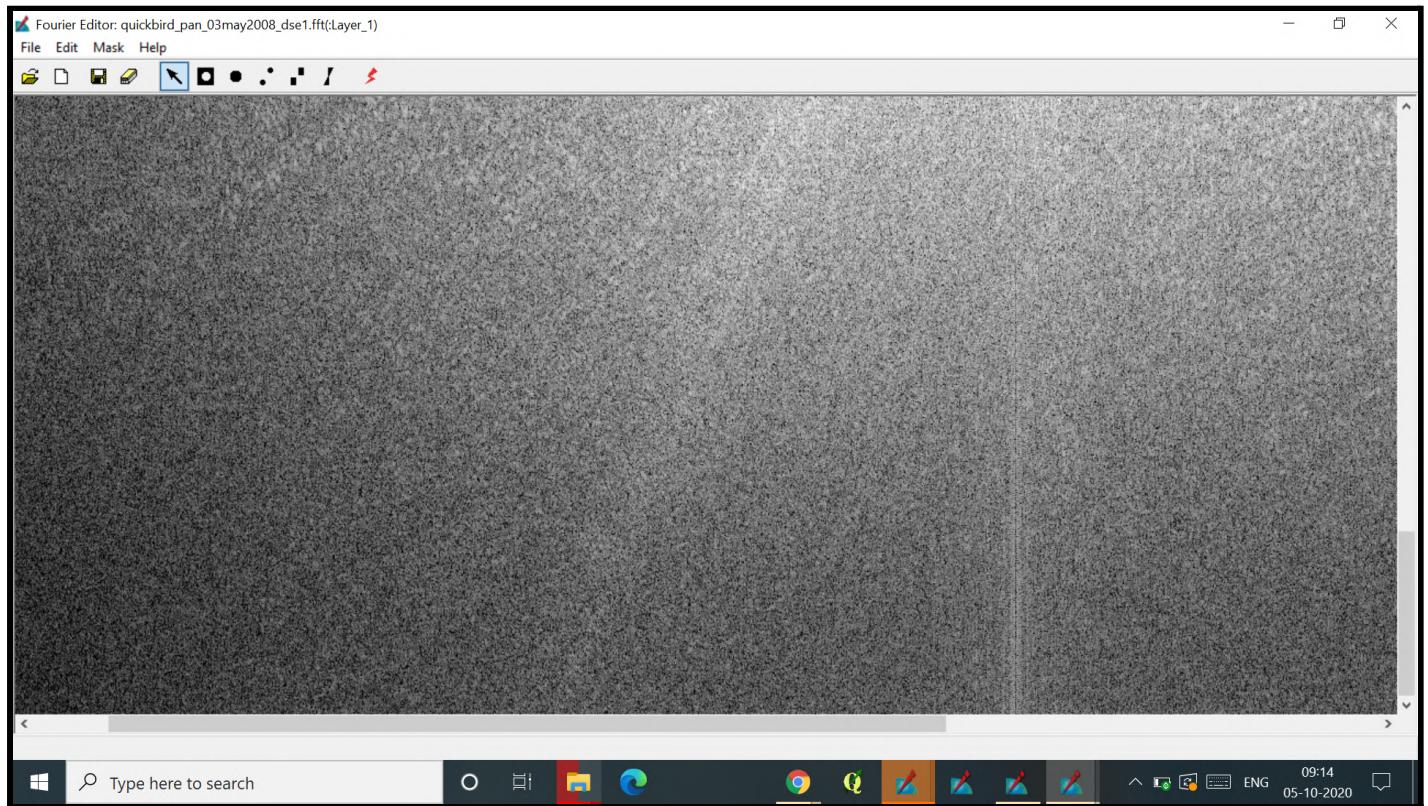
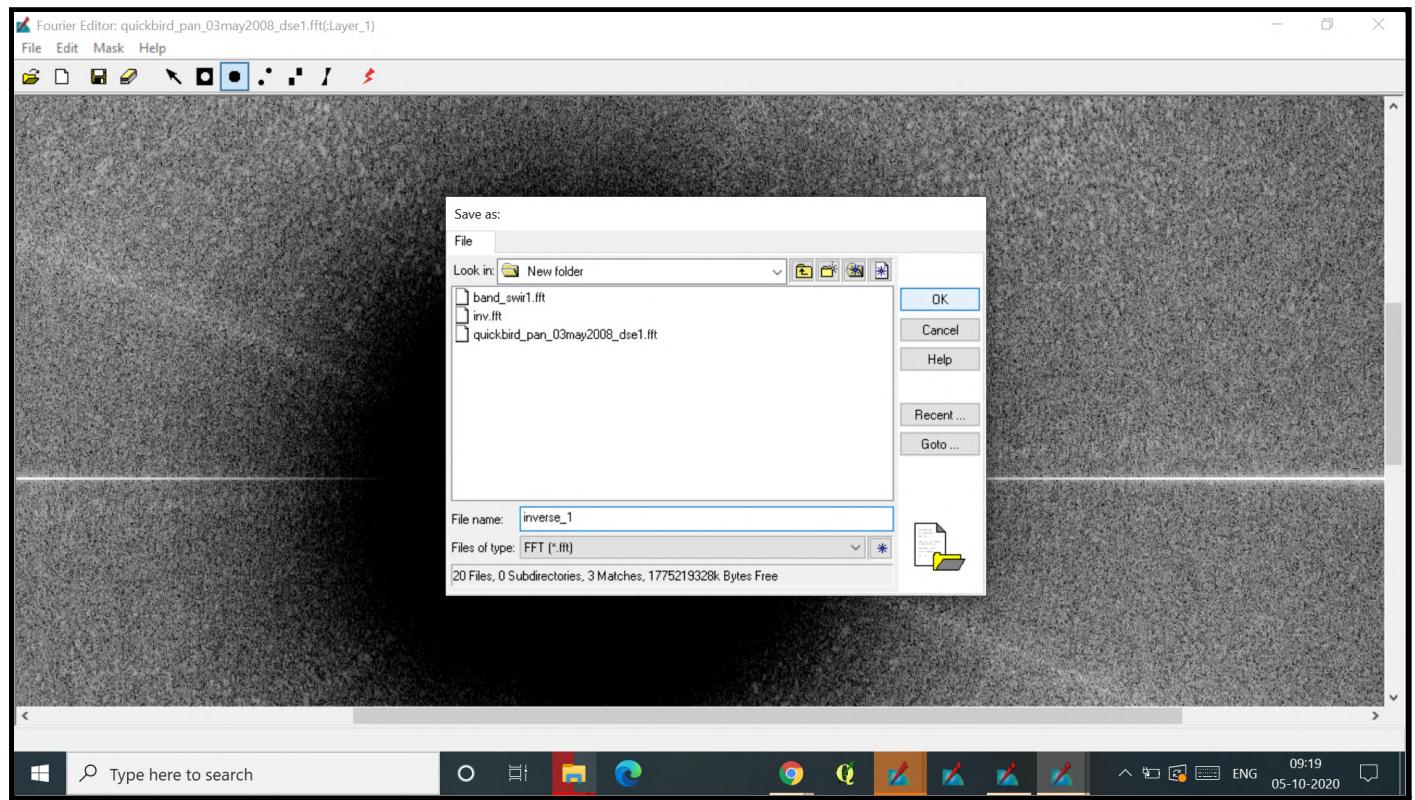


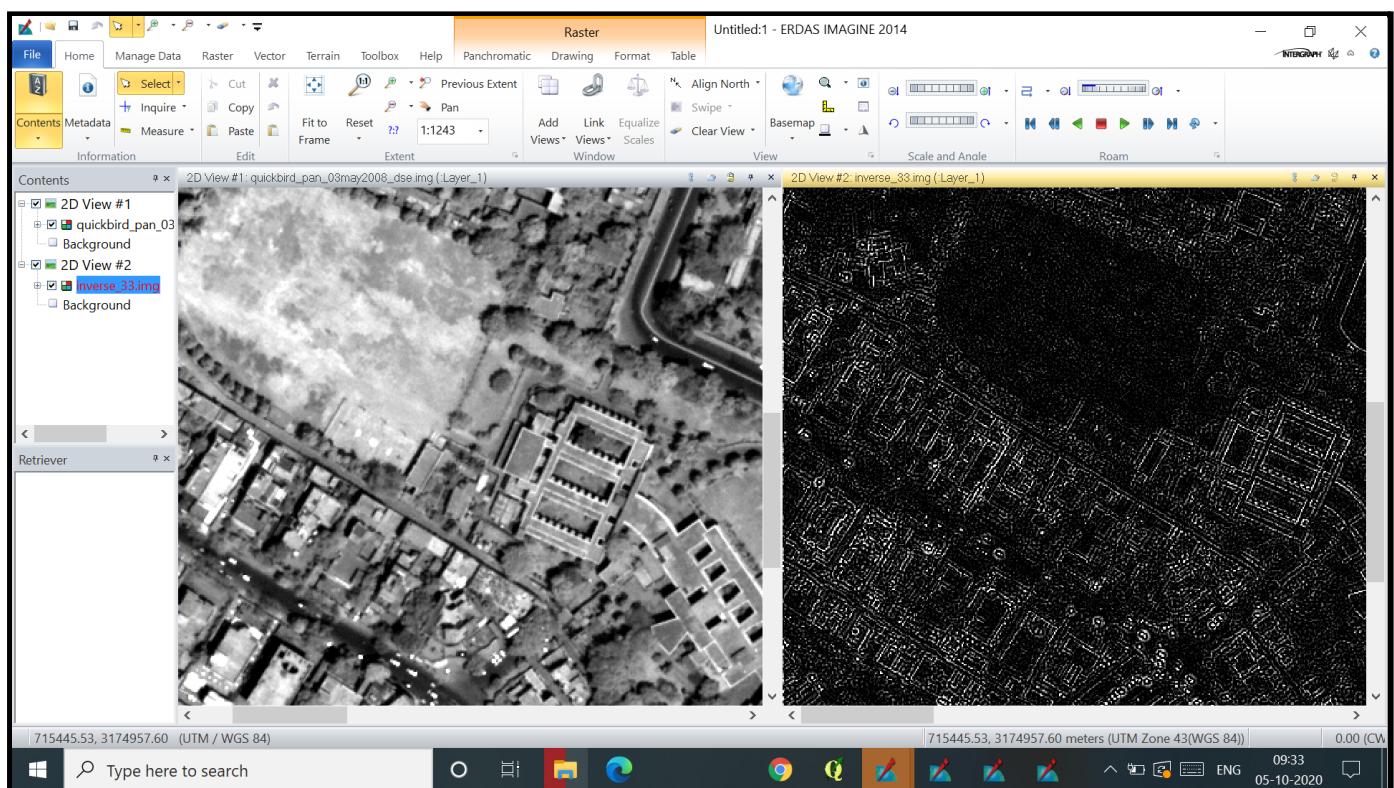
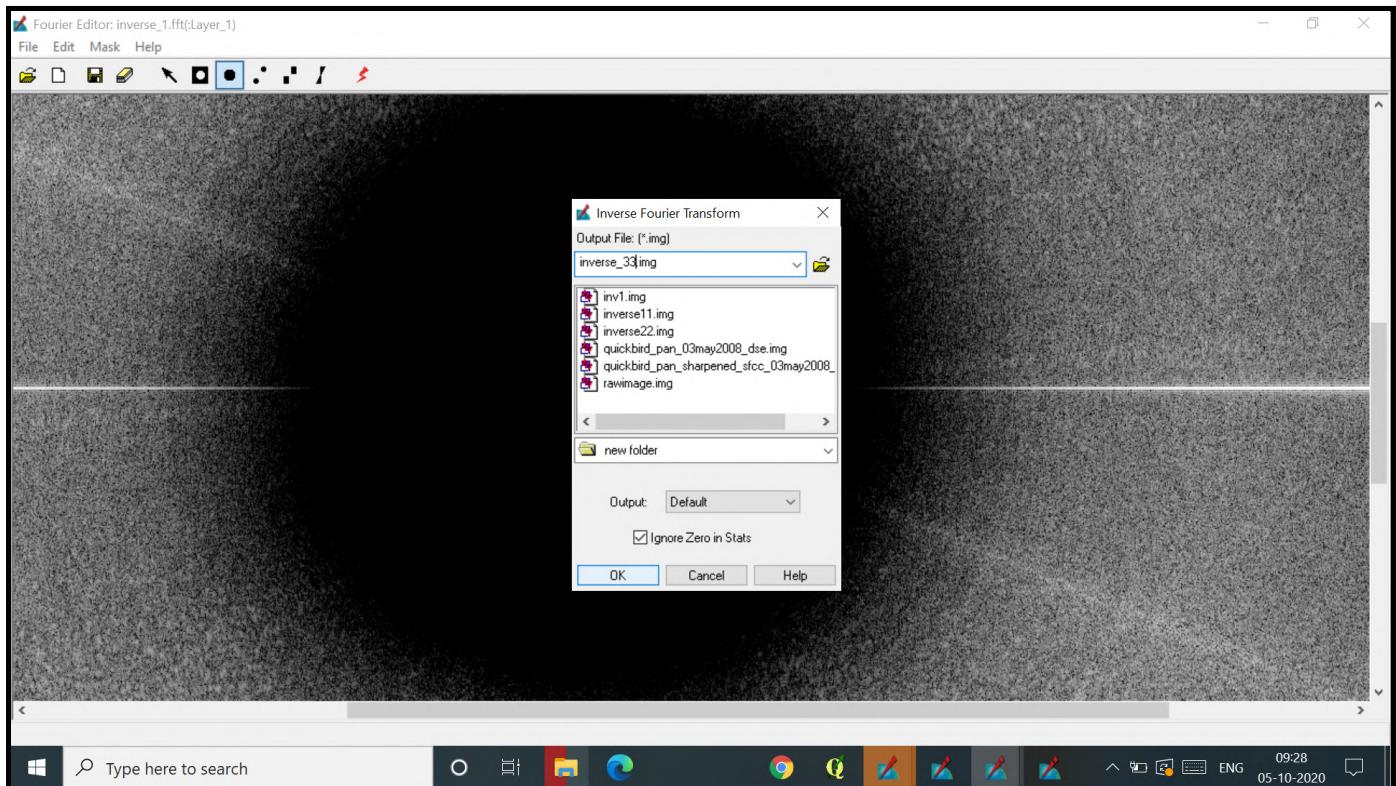
Image converted into frequency domain.



Step-3 After applying the filter, save it(.fft). And then click on **RUN** to execute.

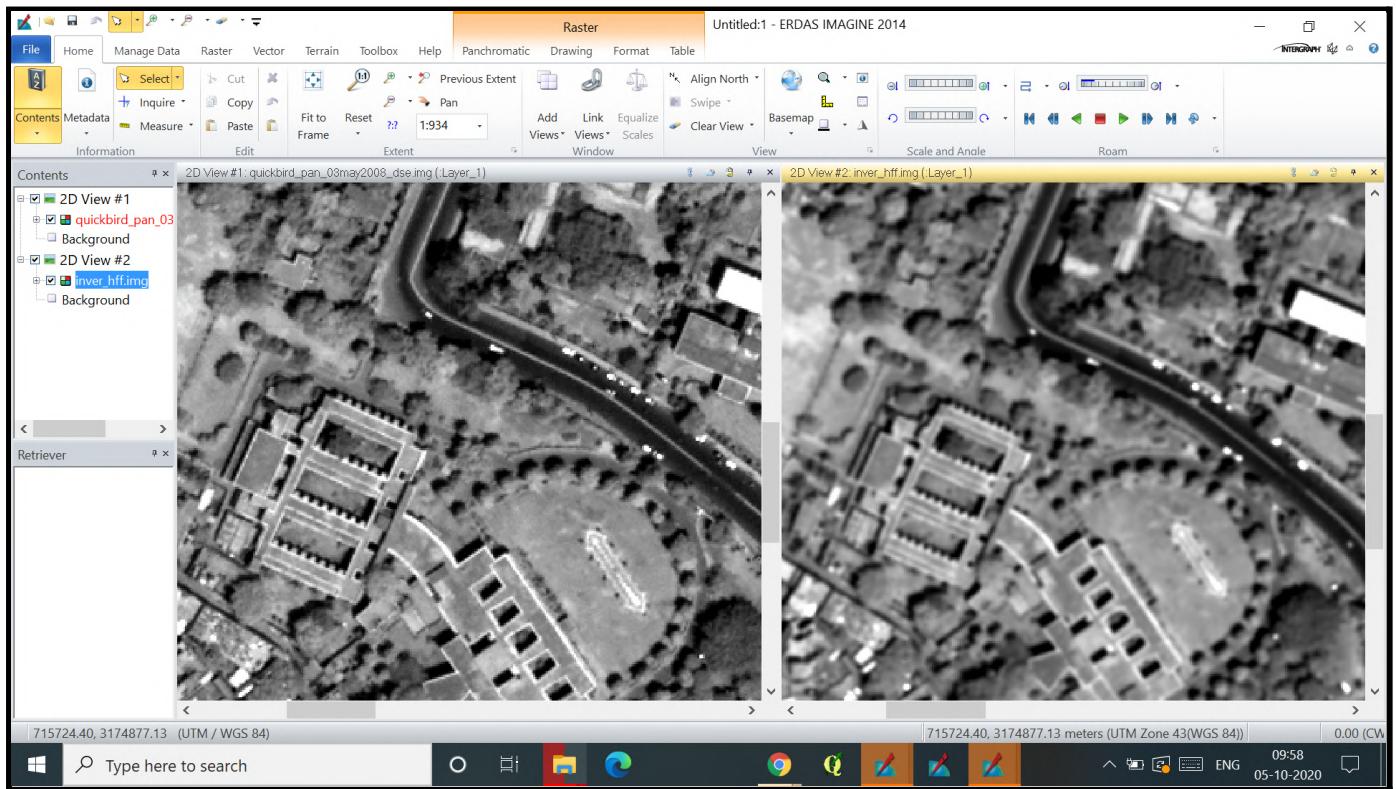


Step-4 Save to Inverse Fourier Transformation (.img) i.e converting back to image domain. And enable ignore 0 in stats. Click ok.



In the above fourier transformation, low frequency has been blocked and **preserves high frequency DN values**. It has enhanced/preserved the **edges and finer details** in images and boundaries can be easily **digitalised**. It enhances overall **sharpness** of image.

Low frequency fourier transformation



In this, the **High DN values are blocked**. This **smoothen** the image by **blurring** the image especially around the edges of the object.

In Fourier transformation, image is **converted into frequency domain** and then again reversed back to image domain. The low frequency is at centre. Fourier Transformation is **highly flexible** in data processing by **blocking high/low frequency components**. Can also **apply directional/ edge filters**. The **systematic stripes** (Variation in frequency) can also be removed using this transformation. And **non-systematic errors** can also be removed if one can identify its frequency.