Overlay Operations :

The hallmark of GIS is overlay operations. The capability to overlay multiple data layers in a vertical fashion is the most required and common technique in geographic data processing. ~~Infact the use~~

Topological overlay is predominantly concerned with overlaying polygon data with polygon data eg: soils and forest cover. However, there are requirements for overlaying point, linear, and polygon data in selected combinations eg: point-in-polygon, line-on-polygon and polygon-on-polygon are the most common. Vector and raster based software differ considerably in their approch to overlay

Raster-based software is oriented towards arithmetic overlay operations, eg, the addition, subtraction, division, and multiplication of data layers. The nature of the one-attribute map approach, typical of the raster data model usually provides a more flexible and efficient overlay capability. The raster data model affords a strong numerically modelling capability. Most sophisticated spatial modelling is undertaken within the raster domain.

In vector-based systems, topological overlay is achieved by the creation of a new topological theme from two or more existing themes. This requires the rebuilding of topological tables. eg, arc, node, polygon and therefore can be time-consuming and CPU-intensive. The result of a topological overlay in the vector domain is a new topological theme that contains attributes of the original input data layers. In this way, selecte queries of the original layer can then be undertaken, eg, soils and forest cover, to determine where specific situations occur, eg., deciduous forest cover where drainage is poor.

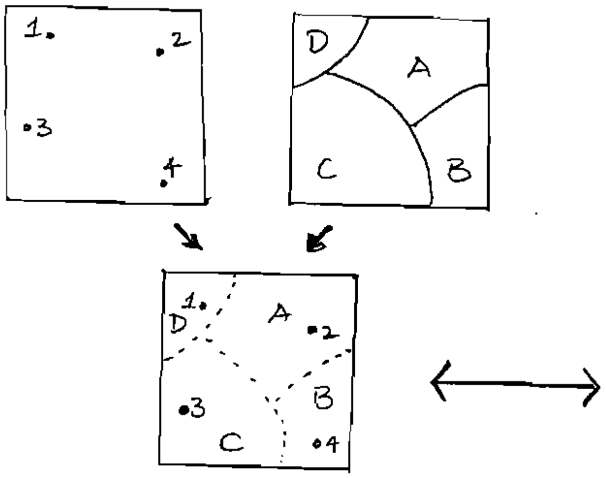
Vector Overlay:

Overlay of vector data is slightly complicated because it must update the topological tables of spatial relationships between points, lines, and polygons. During the process of overlay, the attribute data associated with each feature type are merged. The resulting table contains both the attribute data. The process of overlay depends upon the modelling approach the user needs. Generally, GIS software implements the overlay of differer vector data layers by combining the spatial and attribut data files of the layers to create a new data layer. Again, different GIS software ~~implements the overlay of different~~ utilize varying approaches for the display and reporting of overlay results. Some systems require that topological overlay occur on only two data layers at a time, creating a third layer. One might need to carry out a series of overlay procedures to arrive at the conclusion, which depends upon some criteria.

There are three types of vector overlay, point-in-polygon, line-on-polygon and polygon-on-polygor

Point-in-Polygon Overlay:

Points are overlaid on a polygon map. Topology of point in polygon is 'is contained in' relationship. Point topology in the new data layer is a new attribute of polygon for each point.

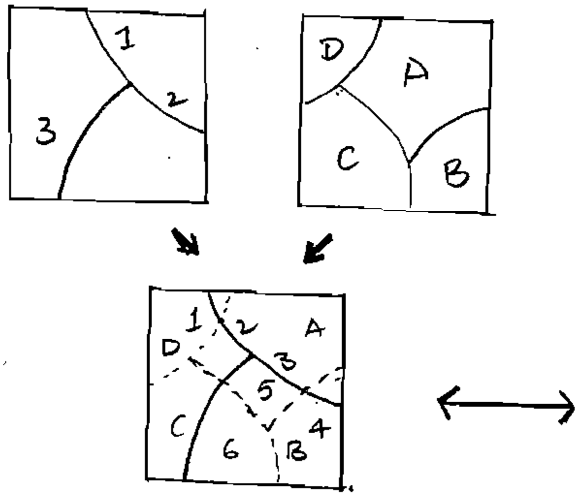


Point topology

ID	owner	Land use
1	Mayer	D
2	clinton	A
3	Bush	C
4	Lee	B

Line-on-Polygon Overlay:

Lines are overlaid on a polygon map with broken line objects. Topology of line on polygon is 'is contained i relationship. Line topology in new data layer is the attribute of old line ID and containing area ID.

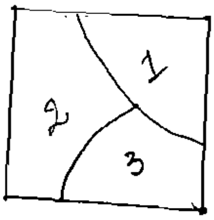


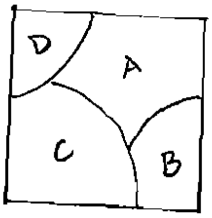
Line topology

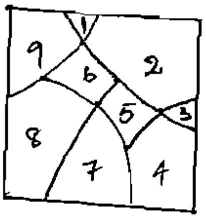
ID	Road	Land use
1	1	D
2	1	A
3	2	A
4	2	B
5	3	A
6	3	C

Polygon - on - Polygon Overlay:

Two layers of area objectives are overlaid, resulti in new polygons and intersections. The number of new polygo is usually larger than that of the original polygons. polygo topology in the new data layer is a list of original polygon IDs.







ID	Provinces	Land use
1	1	D
2	1	A
3	1	B
4	3	B
5	3	A
6	2	A
7	3	C
8	2	C
9	2	D

Raster Overlay:

In the raster data structure everything is represented by gird cells. A point is represented by a single cell, a line by a string of cells and an area by a group of cells. Therefore the method of overlaying various thematic layers are different from vector overlay Raster overlay can be performed by using map algebra or mathematics. Using map algebra input layers may be added, subtractid, multiplied or divided to produce an output value. This most important function in raster overlay, is basically an operation of entities like appropria coding point, line and area features in the input data laye

To understand the concept of raster overlay and map algebra, consider a terrain which consists of four thematic layers, namely, well stations, the road network, the land use, and boundaries of water bodies. Let the well stations be represented in a raster data layer for which the value '1' has been given. Similarly road network are coded '2' in the road network layer, the land use patterns are coded '3' in the land use layers and '4' for the boundaries of water bodies. On all days layers '0' is the value given to cells that do not contain any information content. The raster overlay using map algebra is

1	0	0	0	0
0	1	0	0	0
0	0	0	0	0
0	0	1	0	0
1	0	0	0	1

Well stations

+

1	1	1	0	0
0	1	1	1	1
0	0	1	0	0
1	1	1	0	0
0	0	1	0	0

Road Network

+

3	2	2	1	1
1	3	3	2	2
1	1	1	1	1
2	3	4	2	2
2	1	2	1	2

Resulting Map

+

1	1	1	1	1
0	0	1	1	1
0	1	0	0	0
1	1	1	1	1
1	1	1	1	1

Land use

+

0	0	0	0	0
1	1	1	0	0
1	0	0	1	1
0	1	1	1	1
0	0	0	0	0

Water Boundary

1: presence of feature
0: Absence of feature

By using the concept of point-in-polygon, line-in-polygo and polygon-on-polygon, the output integratid layers with the various combinations of these raster data layers can be produced by the method of map algebra. The algebraic manipulation of images in raster GIS is a powerful and flexible way of combining, integrating and orgainising the data analysis models. Equations can be developed with variables to allow the creation of spatial models.

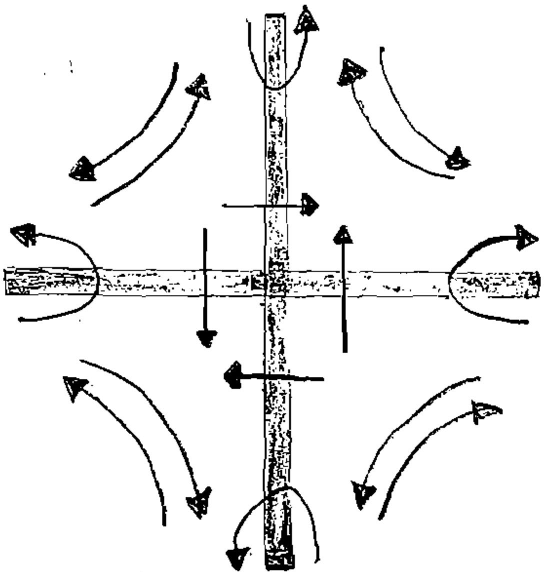
Two issues are specifically considered in performin raster overlay, resolution and scales/levels of measurement. These two parameters of digital data effect the results of raster overlay modelling. Consideration of these two issues are very much useful in reducing the degree of uncertainty and improving the accuracy and precision of GIS data analysis.

NET WORK ANALYSIS :

The movement of people, the transportation, and distribution of goods and services, the delivery of resources and energy, and the communication of information all occur through definable network systems. Network connectivity is based on geometric coincidence, hence the name geometric network. A geometric network has a corresponding logical network. The geometric network is the actual set of feature classes that make up the network. The logical network is the representation of the network connectivity. Each element in the logical network is associated with a feature in the geometric network.

Network models are based on interconnecting logical components, of which the most important are

→ 'Nodes' define start, end, and intersection
→ 'chains' are Lines features joining nodes.



Network Tracing:

Network tracing finds a particular path through the network, based on criteria provided by the user. For example, finding a path that connects the nearest ATM of a specific bank, considering the user does not know the location of the ATM.

Network Routing:

Network determines the optimal path along a linear network. Some possible criteria to select the path include shortest distance, fastest distance, or minimum cost from a position on the network to a known location. It can also be 'point to point' i.e., source to destination or 'point-to-multiple-point' i.e., with intermediate stops from source to destination. One example of point-to-point is the shortest path from India Gate to Parliament House. Example of point-to-multiple-point is shortest path from India Gate to ~~po~~ Parliament House which passes by a specified hospital.

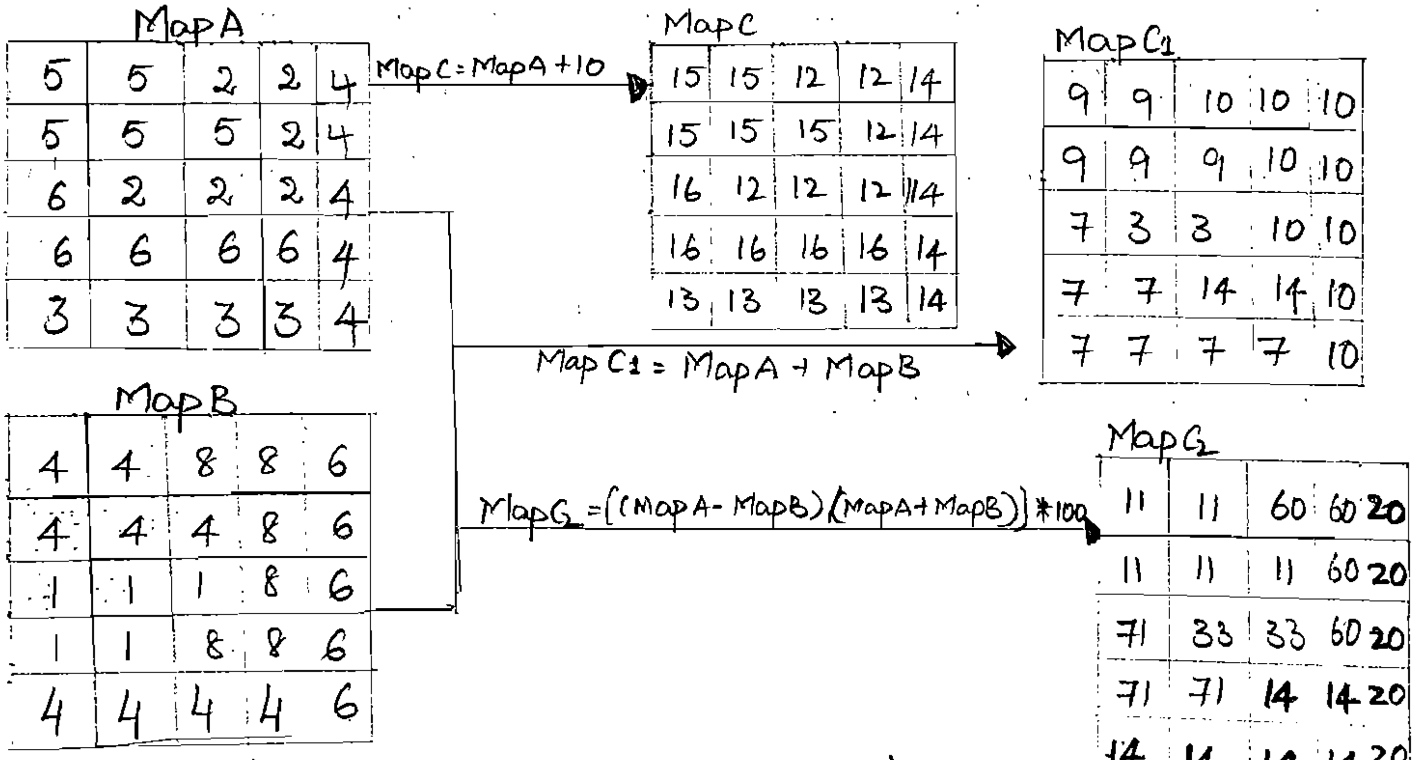
Network Allocation:

Network allocation deals with the designation of portions of the network to 'supply centres' or 'destinatio points'. Such points can be, for example, a fire statio This example also shows the amount of overlap betwee the service areas of two fire stations. Fire services are therefore able to optimize their response times by forming a plan based on this information. Even in cases such as this, when relocating a distribution centre is impractical, such information can prove valuable information protocols.

Arithmetic Operators:

Arithmetic operators are the simplest operators. They are used for multiplication, division, subtraction or addition of maps and/or constant values. It is obviou that arithmetic operators can only be used on values maps, and not on maps containing classes.

Syntax	operation	Example
+	Add	a+b
-	subtract	a-b
*	Multiply	a*b
/	Divide	
^	Exponential operator, POW (a,b), a^b	a^b
a DIV b	Returns the quotient of a divided by b	a DIV b



MapA

5	5	2	2	4
5	5	5	2	4
6	2	2	2	4
6	6	6	6	4
3	3	3	3	4

MapB

4	4	8	8	6
4	4	4	8	6
1	1	1	8	6
1	1	8	8	6
4	4	4	4	6

MapC

15	15	12	12	14
15	15	15	12	14
16	12	12	12	14
16	16	16	16	14
13	13	13	13	14

MapC1

9	9	10	10	10
9	9	9	10	10
7	3	3	10	10
7	7	14	14	10
7	7	7	7	10

MapG

11	11	60	60	**20**
11	11	11	60	**20**
71	33	33	60	**20**
71	71	**14**	**14**	20
14	**14**	**14**	**14**	20

Negative values in the map G are shown in bold

Let us look at the simplest one:

Map C = Map A + 10

This means: Add a constant factor of 10 to all pixel values of raster map MapA and store the result in output map Map C. In other words MapC is equal to the sum of raster map MapA and a constant value of 10.

The second calculation is:

Map C1 = MapA + MapB

This means add the pixel values of MapA and MapB and store the result is MapC1

The third calculation is:

Map C2 = [(Map A - MapB) / (MapA + MapB)] * 100

This means: Store raster map MapC2, which is the result of the subtraction of MapB for MapA, divided by the sum of MapA and MapB; then multiply this by 100. This formula when applied on two satellite bands MapB with visible or red values and the MapA with near-infra-red values is called the NDVI (Normalized Difference Vegetation Index). The output values range from -100 to +100.

Logical Operators :

Overlay analysis manipulates spatial data organized in different layers to create combined spatial features according to logical conditions specified in Boolean algebra with the help of logical and conditional operators. The logical conditions are specified with operands (data elements) and operators (relationships among data elements)

Common logical operators include AND, OR, XOR (Exclusive OR), and NOT. Each operation is characterized by specific logical checks of decision criteria to determine if a condition is true ~~to~~ or false. The table below shows the true/false conditions of the most common Boolean operations. In this table, A and B are two operands. One (1) implies a true condition and zero (0) implies false. Thus, if the A condition is true while the B condition is false, then the combined condition of A and B is false. Where as the combined condition of A OR B is true

AND – Common Area / Intersection / Clipping Operatio

OR – Union Or Addition

NOT – (Inverter)

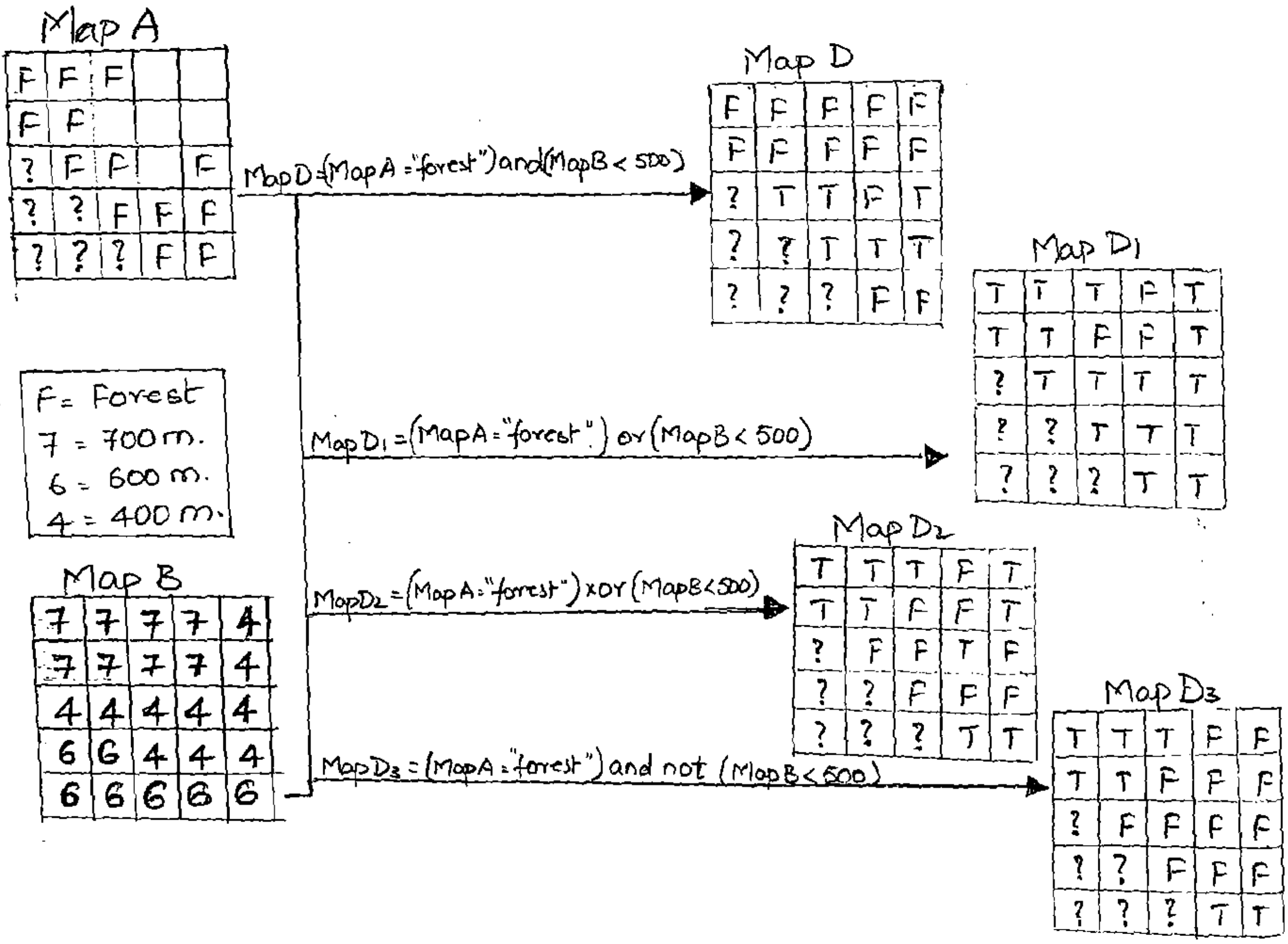
XOR – Minus

A	B	A AND B	A OR B	A NOT B	B NOT A	A XOR B
0	0	0	0	0	0	0
0	1	0	1	0	1	0
1	0	0	1	1	0	1
1	1	1	1	0	0	0

Logical operators used in Map calculation. They can be used on maps, with all types of domains.

Syntax	Operation	Example
AND	Returns true if both expressions a and b are true	(a) AND (b)
OR	Returns true if one or both of the expressions a and b is true	(a) OR (b)
XOR	Returns true if only one of the expressions a and b is true	(a) XOR (b)
NOT	Returns true if expression b is false	NOT (b)

Logical operators (above table) compare two expression and check if both are true (AND), at least one is true (OR), only one is true (XOR), or one is not true (NOT).



Map A

F	F	F		
F	F			
?	F	F		F
?	?	F	F	F
?	?	?	F	F

Map B

7	7	7	7	4
7	7	7	7	4
4	4	4	4	4
6	6	4	4	4
6	6	6	6	6

Map D

F	F	F	F	F
F	F	F	F	F
?	T	T	F	T
?	?	T	T	T
?	?	?	F	F

Map D1

T	T	T	F	T
T	T	F	F	T
?	T	T	T	T
?	?	T	T	T
?	?	?	T	T

Map D2

T	T	T	F	T
T	T	F	F	T
?	F	F	T	F
?	?	F	F	F
?	?	?	T	T

Map D3

T	T	T	F	F
T	T	F	F	F
?	F	F	F	F
?	?	F	F	F
?	?	?	T	T

The above figure is the example of logical operations. MapA has domain type class and Map B has domaine type value. The output is either True(1), False(0) or undefined(?)

These operators are also called Boolean operators. Examples of Boolean operators (AND, OR, XOR, NOT) are presented in above figure.

Map D = (MapA = "Forest") AND (MapB < 500)

When a pixel in MapA has class name 'Forest' and at the same time this pixel in MapB has a value less than 500, assign value True(1) to this pixel in the output map (MapD). Assign value False (0) to all othe pixels.

Map D_1 = (MapA = "Forest") OR (MapB < 500)

The expression is true if only 1 of the expressions is true or both of the 2 expressions are true.

- if a pixel in mapA has class name Forest and in MapB not smaller than 500.
- if that pixel in MapB has a value <500 and in MapA not Forest.
- if a pixel in MapA is Forest and if that pixel in MapB<500.

otherwise the whole expression is false.

Map D_2 = (MapA = "Forest") XOR (MapB <500)

The expression is true if only 1 of the 2 expressions is true.

- if a pixel in MapA is Forest and in MapB not smaller than 500.
- if a pixel in MapB<500 and in MapA not Forest.

otherwise the whole expression is false. This statemen is called exclusive OR.

Map D_3 = (MapA = "Forest") AND NOT (MapB<500)

When a pixel in mapA has class name Forest and at the same time this pixel in MapB does not have a value less than 500, assign True (1) to this pixel in the output map (return True(1) if the first condition is true and the second is false). Assign False (0) for all pixels where this is not the case.

Conditional Expression:

The examples that we have used for the relational and logical operators all give output values, which are either true or false. In practice we use these operators mostly with the so-called conditional iff function The general syntax for the conditional iff function is:

Output_map = IFF (Condition, Then Expression, Else Expression)

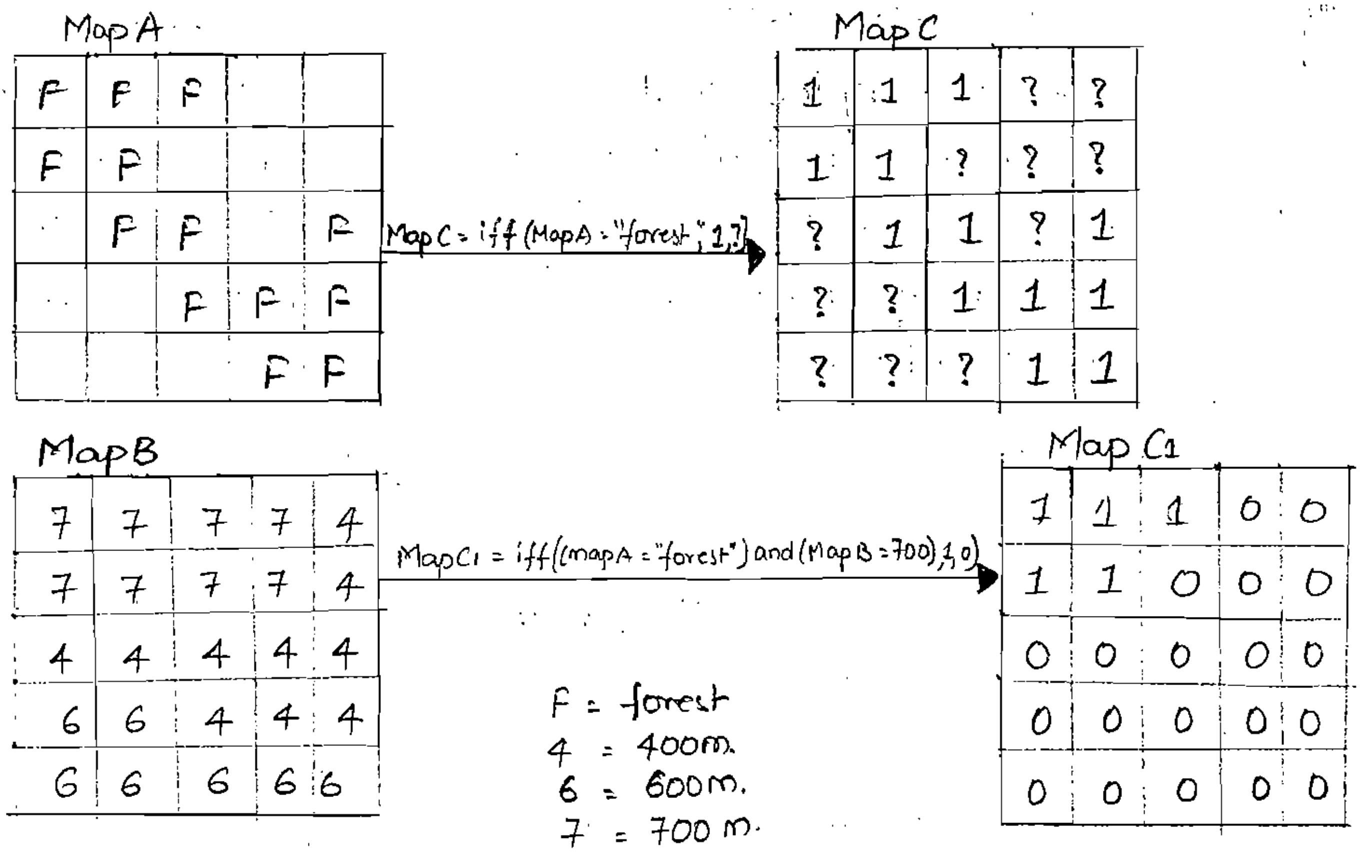
or

Output_map:= IFF (Condition, Then Expression, Else Expression)

Where:

Output_map	Is the name of output map
=	Is the definition to creat a dependent output map
:=	Is the assignment to creat a non-dependent (editable) output map.
IFF	Is the conditional function
Condition	Is the condition to be met
Then Expression	Is the calculation that has to be performed when the condition is met.
Else Expression	Is the calculation that has to be performe when the condition is not met.

Some examples of the use of conditional functions is



Map A

F	F	F		
F	F			
	F	F		F
		F	F	F
			F	F

Map C

1	1	1	?	?
1	1	?	?	?
?	1	1	?	1
?	?	1	1	1
?	?	?	1	1

Map B

7	7	7	7	4
7	7	7	7	4
4	4	4	4	4
6	6	4	4	4
6	6	6	6	6

Map C_1

1	1	1	0	0
1	1	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0

F = forest
4 = 400m.
6 = 600m.
7 = 700 m.

For simplification purpose, expression for Then condition and the Else condition are not used but simply a value will be given.

Map C = IFF (MapA = "Forest", 1, ?)

In words : If a pixel in MapA has a class name Forest, then assign a value 1 to this pixel in the output map (Mapc). If the pixel does not have the class Forest, then assign the undefined value (?)

Map C_1 = IFF ((MAP A = "Forest") AND (MapB = 700), 1, 0)

In Words : If a pixel in Map A has a class name Forest and at the same time this pixel in Map B has a value equal to 700, then asign a value 1 to this pixel in the output map ; else asign value 0.

Comparison Operators :

Comparison operators are used to specify conditions on the non-spatial attributes of a feature. The comparison operators are

- Property Is Equal To
- Property is Not Equal To
- Property Is less Than
- Property Is Less Than or Equal To
- Property Is Greater Than
- Property Is Greater Than or Equal To

These operators contain two filter Expression to be compared. The first operand is often a property Name but both operands may be any expression, function or literal value.