USING SATELLITE IMAGERY AND GIS FOR MAPPING FOREST FIRE RISK ZONES AND IN HOTSPOTS ANALYSIS IN THE NORTHWEST REGION, VIETNAM

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OUTLINE

- CONTEXT
- OBJECTIVE OF STUDY
- APPROACH USED
- RESULTS
- CONCLUSION

FOREST AREA AND FOREST FIRE IN VIETNAM

- VIETNAM WITH **13,258,843 HA (2010).** IN DRY SEASON THERE ARE ABOUT **6 MILLIONS HA** OF FOREST AND PLANT VEGETABLE (ABOUT **50%**OF TOTAL FOREST AREA) WITH HIGH POTENTIAL OF FOREST FIRE RISK, LOCATED IN 48 DIFFERENT PROVINCES AND CITIES.

- FOREST TYPES, WHICH EASY TO CATCH FIRE INCLUDING: ***PINE, DIPTEROCARPACEAC, INDIGO, CASUARINAS, EUCALYPTUS, BAMBOO FOREST, GRASSLAND AND BRUSH TREES***. HOWEVER, WHEN SEVERE WEATHER AND CLIMATE COMING, ALL THE FOREST TYPES COULD EASY CAST FIRE AND FOREST FIRE HAPPEN IN HIGH FREQUENCY.
- ***FROM DECEMBER OF PREVIOUS YEAR TO APRIL OF THE NEXT YEAR IS A FOREST FIRE SEASON WITH HIGH RISK IN DIFFERENT ECO-REGIONS: NORTH-EAST, NORTH-WEST, PLATEAU, EAST OF SOUTHERN VIETNAM AND MEKONG DELTA RIVER.***

CAUSES OF FOREST FIRE IN VIETNAM

(HOANG MINH HIEN 2007)

- BURNING FOR AGRICULTURE LAND BY ETHNIC MINORITIES; STRAW AND GRASS BURNING IN RICE FIELD. THE FOREST FIRES CAUSING BY THIS KIND OF REASON TAKES ABOUT **20**% OF TOTAL FOREST FIRES.
- LOCAL PEOPLE USING FIRE FOR HUNTING, TRAPPING AND CATCHING WILD ANIMALS IN FOREST, ESPECIALLY USE OF SMOKE TO HARVEST BEE'S HONEY (ABOUT **55**%).
- ILLEGAL ACTIVITIES OF TIMBER, WOOD AND OTHER FOREST PRODUCTS EXPLOITATION, THEY USING FIRE WITHOUT TAKE CONSIDERATION WHEN COOKING, SMOKING ETC.(ABOUT **15**%).
- THE TRADING CONFLICT FROM FOREST RESOURCE EXPLOITATION OF STAKEHOLDERS WITH BURNING FOREST TO HARM OTHER COMPETITORS (ABOUT **10**%).

THE HUMAN ACTIVITIES ARE THE MAJOR CAUSES OF FOREST AND GRASSLAND FIRES IN VIETNAM.

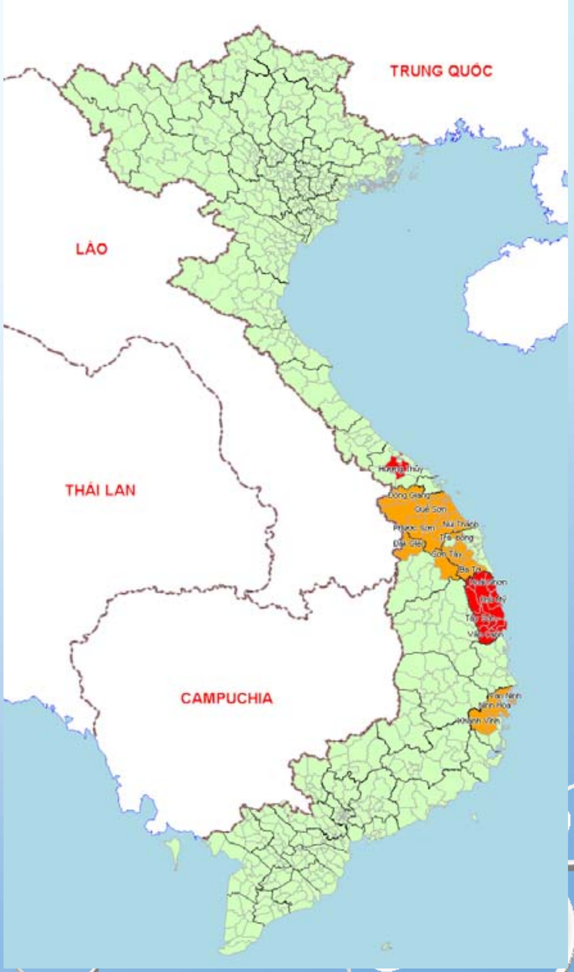
FOREST FIRE RISK WARNING SYSTEM IN VIETNAM

- THE FOREST PROTECTION DEPARTMENT (FPD) BELONGING TO THE MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT (MARD) HAS DEVELOPED A NATIONAL FIRE DANGER RATING.
- FIRE-RELATED WEATHER DATA IS COLLECTED FOR ANALYSIS OF A FOREST FIRE DANGER RATES FOR DISTRIBUTION ACROSS THE COUNTRY.
- THE FIRE DANGER RATING THAT IS MADE AVAILABLE IN RURAL AREAS VIA DIFFERENT MEDIA INCLUDING FACSIMILE, RADIO, TELEVISION AND ROADSIDE SIGNBOARDS.
- FPD THEN HAVE CREATED SPECIAL SOFTWARE WHICH USING THE “NESTEROP” ALGORITHM TO CALCULATE THE LEVELS OF FOREST FIRE RISK OF ALL PROVINCES. THE RESULT OF CALCULATED THE IMMEDIATELY TRANSFER TO VIETNAM RADIO VOICE AND VIETNAM TELEVISION FOR BROADCAST.
- THE FOREST FIRE FORECAST ALSO FIND IN THE WEB OF FPD AND MARD: *HTTP://WWW.KIEMLAM.ORG.VN OR HTTP://KIEMLAM.MARD.GOV.VN*

EXAMPLE MAP OF FOREST FIRE RISK WARNING SYSTEM IN VIETNAM (23/06/2014)

- **LEVEL 3**: IT IS DANGER FOR FOREST FIRE, WHICH IS PRESENTED IN YELLOW COLOR. IN THIS CASE IS NEEDED TO CONSIDER ON FOREST FIRE PREVENTION FOR PINE, EUCALYPTUS, BAMBOO, RUBBER AND INDIGO FOREST ETC.
- **LEVEL 4**: IT IS VERY DANGER OF FOREST FIRE, WHICH IS PRESENTED IN ORANGE COLOR. IT IS A HIGH RISK OF FOREST FIRE IN LARGE SCALE.
- **LEVEL 5**: DRAMATICALLY DANGER OF STRONG FOREST FIRE IN LARGE SCALE WITH QUICK SPREADING. IT IS PRESENTED IN RED COLOR, WHICH MOSTLY HAPPEN IN DROUGHT SEASON.

3	4	5



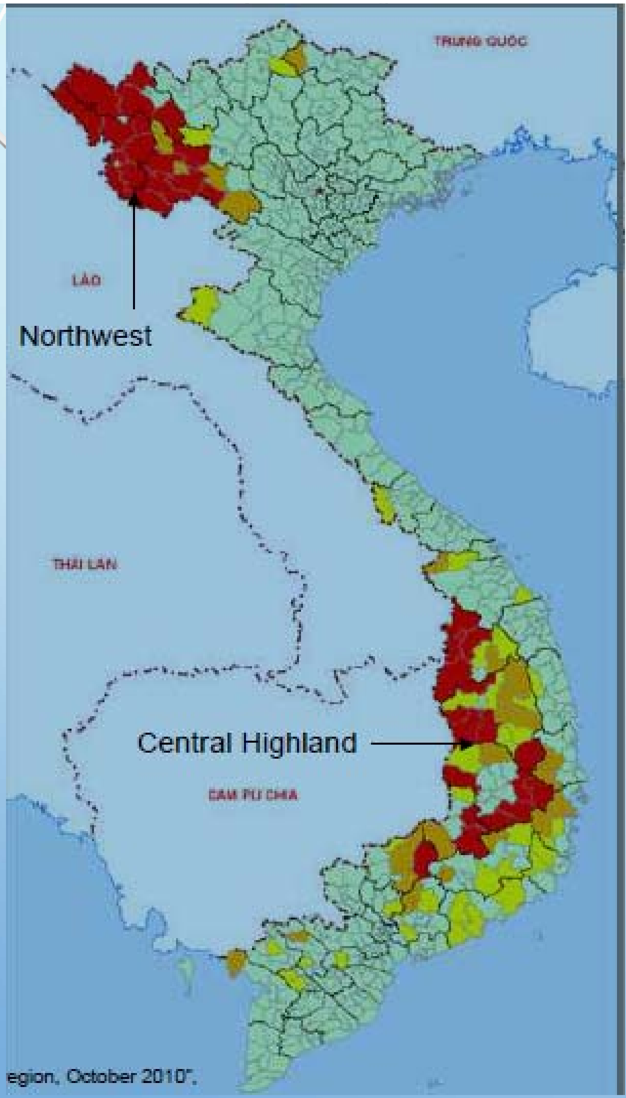
EARLY DETECTION OF FOREST FIRE SPOTS

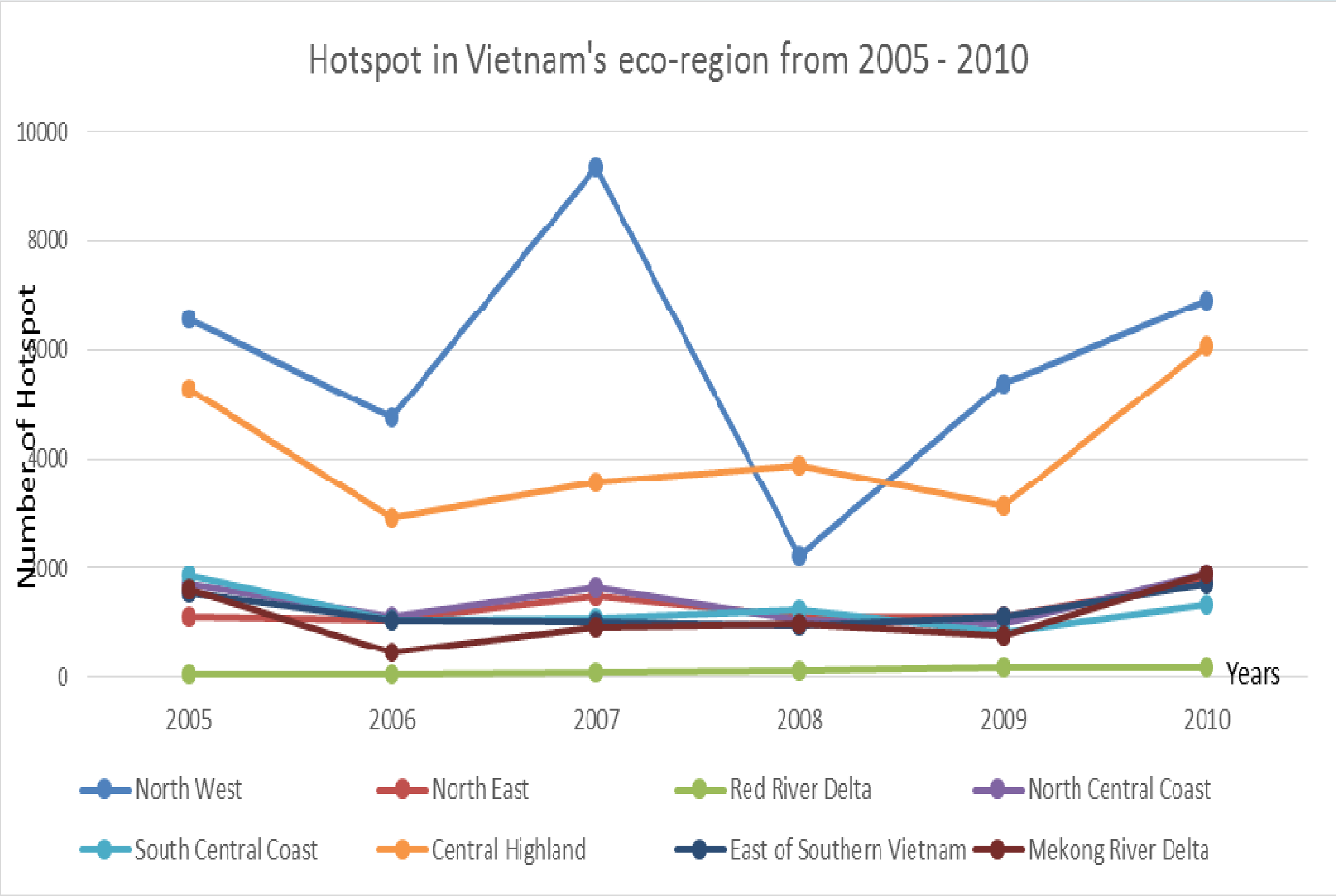
- FPD IN COOPERATION WITH CENTRE OF REMOTE SENSING AND GIS IN ORDER TO APPLY OF TECHNOLOGY TO EARLY DETECTING OF FOREST FIRE. AFTER MODIS AND NOAA (2008) DATA PROCESSING, THE RESULT OF HOT SPOTS WILL BE PUT ON WEBSITE: *HTTP://WWW.KIEMLAM.ORG.VN* *OR* *HTTP://KIEMLAM.MARD.GOV.VN*

WHAT SHOULD INFLUENCE TO FOREST FIRE RISK?

FACTORS LISTED IN EARLIER FIRE RISK ANALYSES INCLUDE LAND COVER (FUEL), SLOPE, ASPECT, SOCIOECONOMIC VARIABLES (NEARBY POPULATION, ROADS, ETC.), TEMPERATURE, AND RELATIVE HUMIDITY (CHUVIECO AND CONGALTON, 1989; CARRÃO, FREIRE, AND CATEANO, 2003; BONAZOUNTAS, KALLIDROMITOU, KASSOMENOS, AND PASSAS, 2005).

THE REGION IS BORDERED BY LAOS TO THE WEST AND CHINA TO THE NORTH. COVERED BY A NUMBER OF PROMINENT MOUNTAINS, THE TYPOGRAPHY INCLUDES A 180KM LONG MOUNTAIN RANGE THAT CUTS DIAGONALLY ACROSS THE REGION FROM NORTHWEST TO SOUTHEAST. SEVERAL PEAKS ALONG THE MOUNTAIN RANGE REACH 3,000 METERS, INCLUDING THE SO-CALLED “ROOF OF INDOCHINA,” FANSIPAN MOUNTAIN

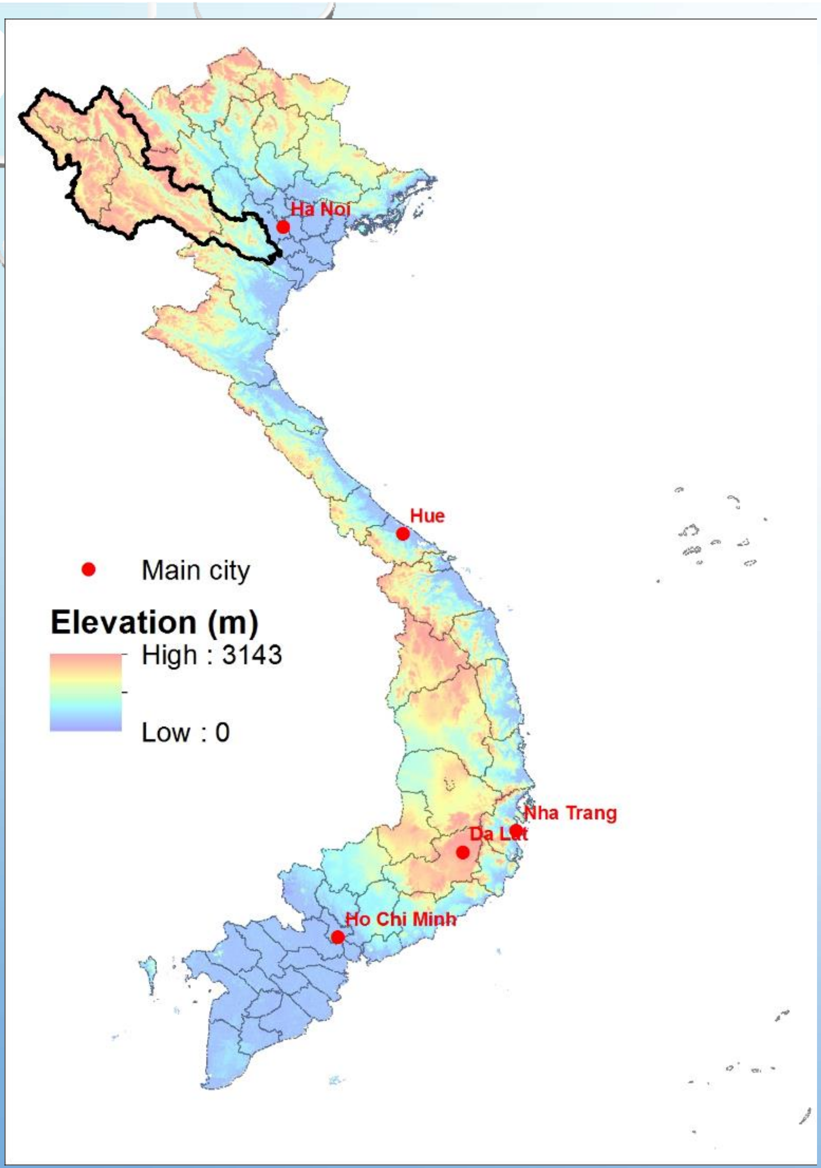




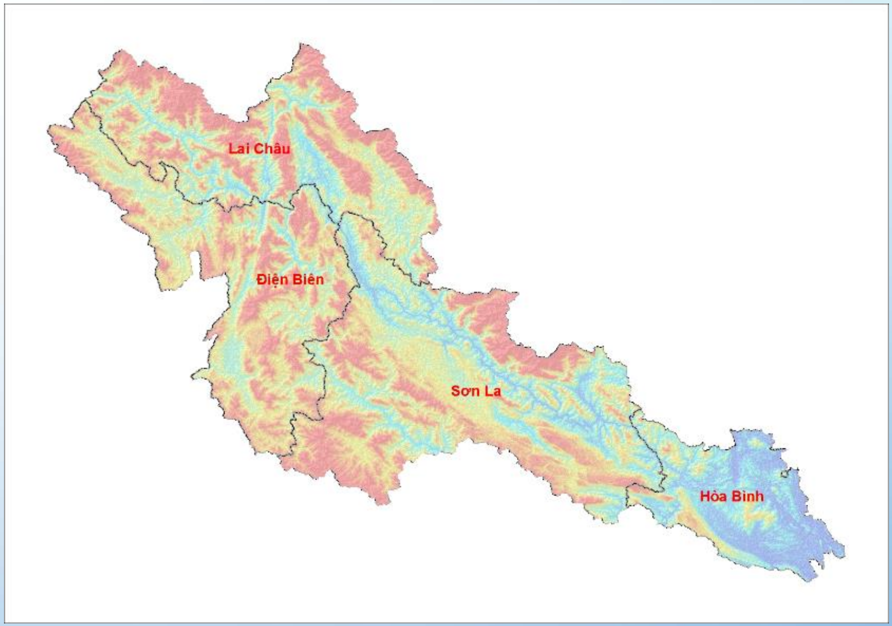
Hotspot area of forest fire in Vietnam

OBJECTIVE

- USING SPATIAL ANALYSIS TO ASSESS FOREST FIRE RISK BASED ON HOT SPOT OCCURRENCE BETWEEN 2005 AND 2010 PROVIDED BY FIRMS SYSTEM, AND SURFACE CONDITIONS OF NORTHWEST REGION, VIETNAM
- TESTING THE FIRMS DATA IN ADDED VALUES ANALYSIS IN CONTEXT OF VIETNAM



STUDY AREA



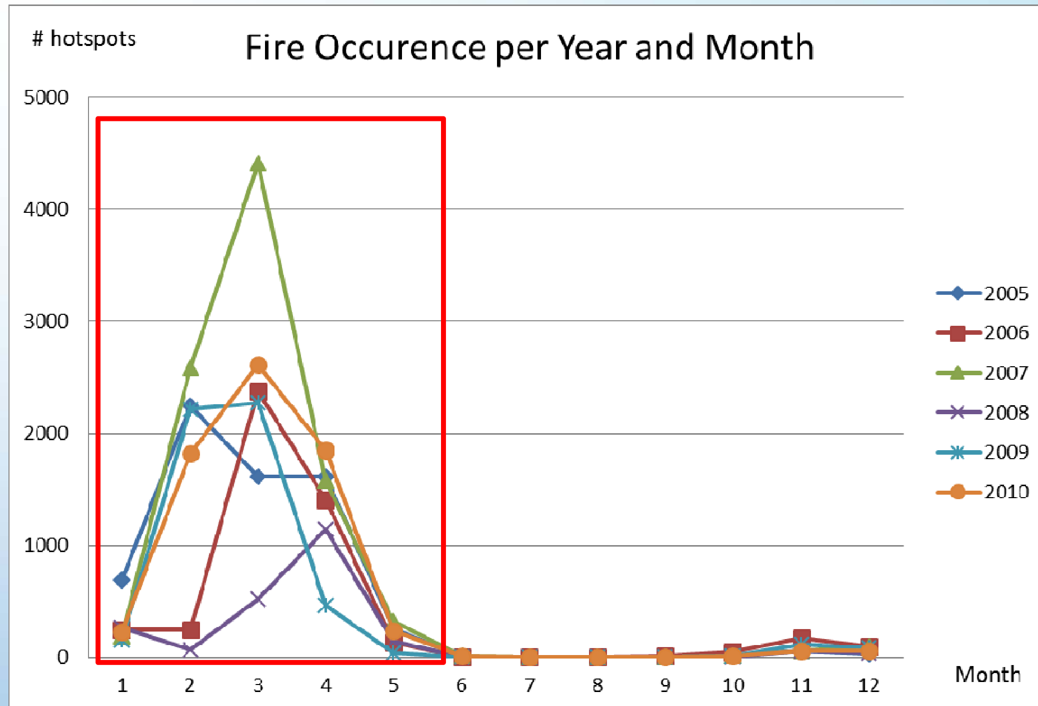
The region is bordered by Laos to the west and China to the north. Covered by a number of prominent mountains, the typography includes a 180km long mountain range that cuts diagonally across the region from northwest to southeast. Several peaks along the mountain range reach 3,000 meters, including the so-called "roof of Indochina," Fansipan Mountain

ACTIVE FIRE OCCURRENCE IN THE VIETNAM AND THE NORTHWEST

Forest Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
East North	+	+	+	+	.						.	+
West North	+	+	+	+	.						.	+
Hong river Delta	+	+	+	+	.						.	+
West Plateau	+	+	+	+	.						.	+
East Southern	+	+	+	+	.						.	+
Cuu Long Delta	+	+	+	+	.						.	+
North Centre					.	+	+	+	.			
Central Coastline			.	+	+	+	.					

Places and month of forest fire in different eco-regions in Vietnam

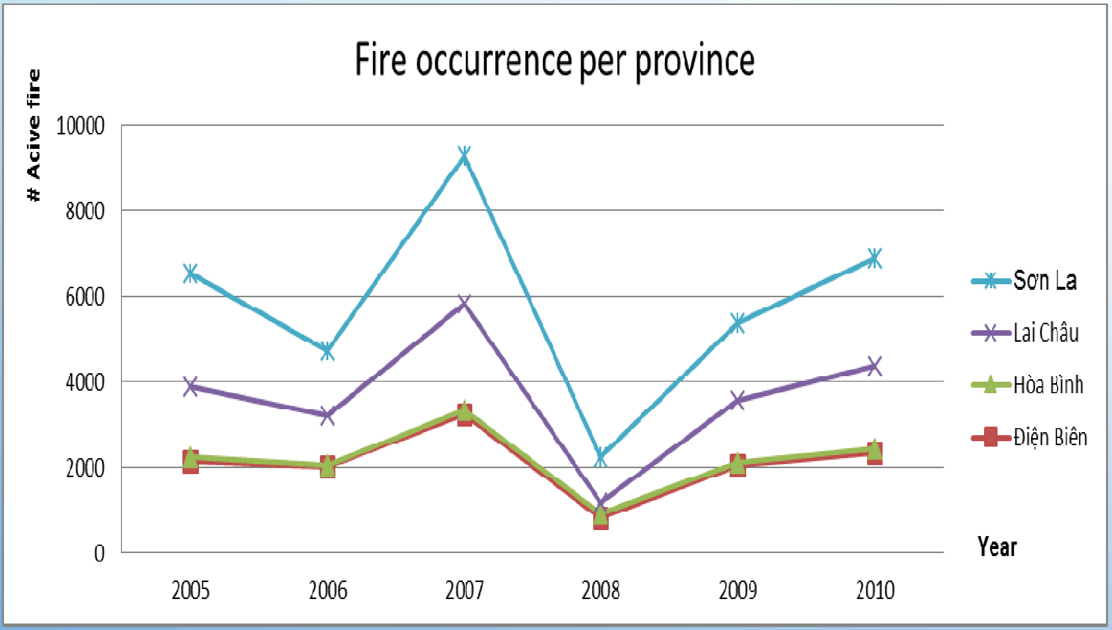
Note:(+) Drought month, danger of forest fire (-) Dry month, risk of forest fire

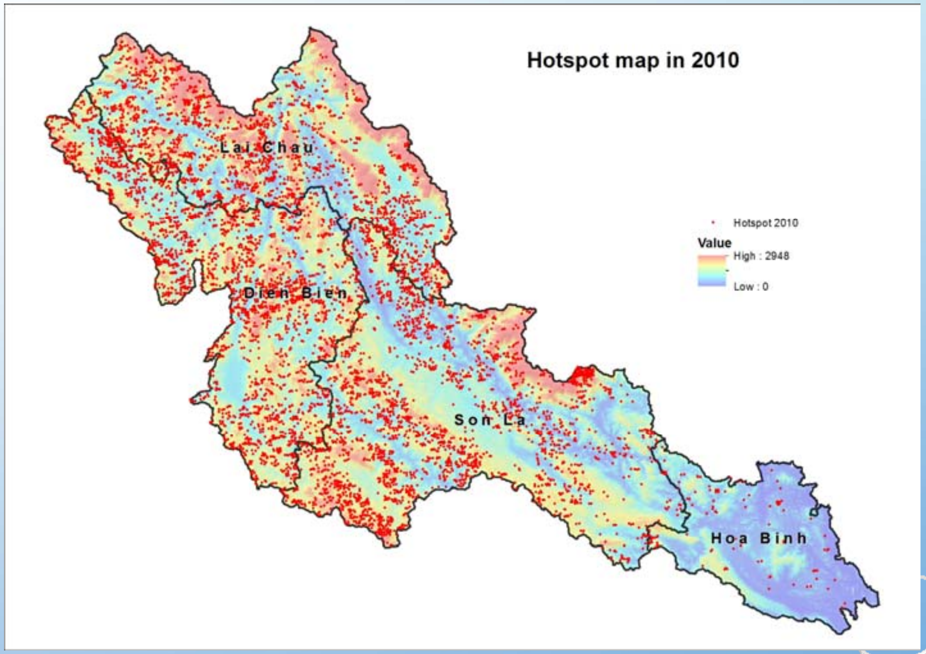


In the Northwest, Vietnam in 2010

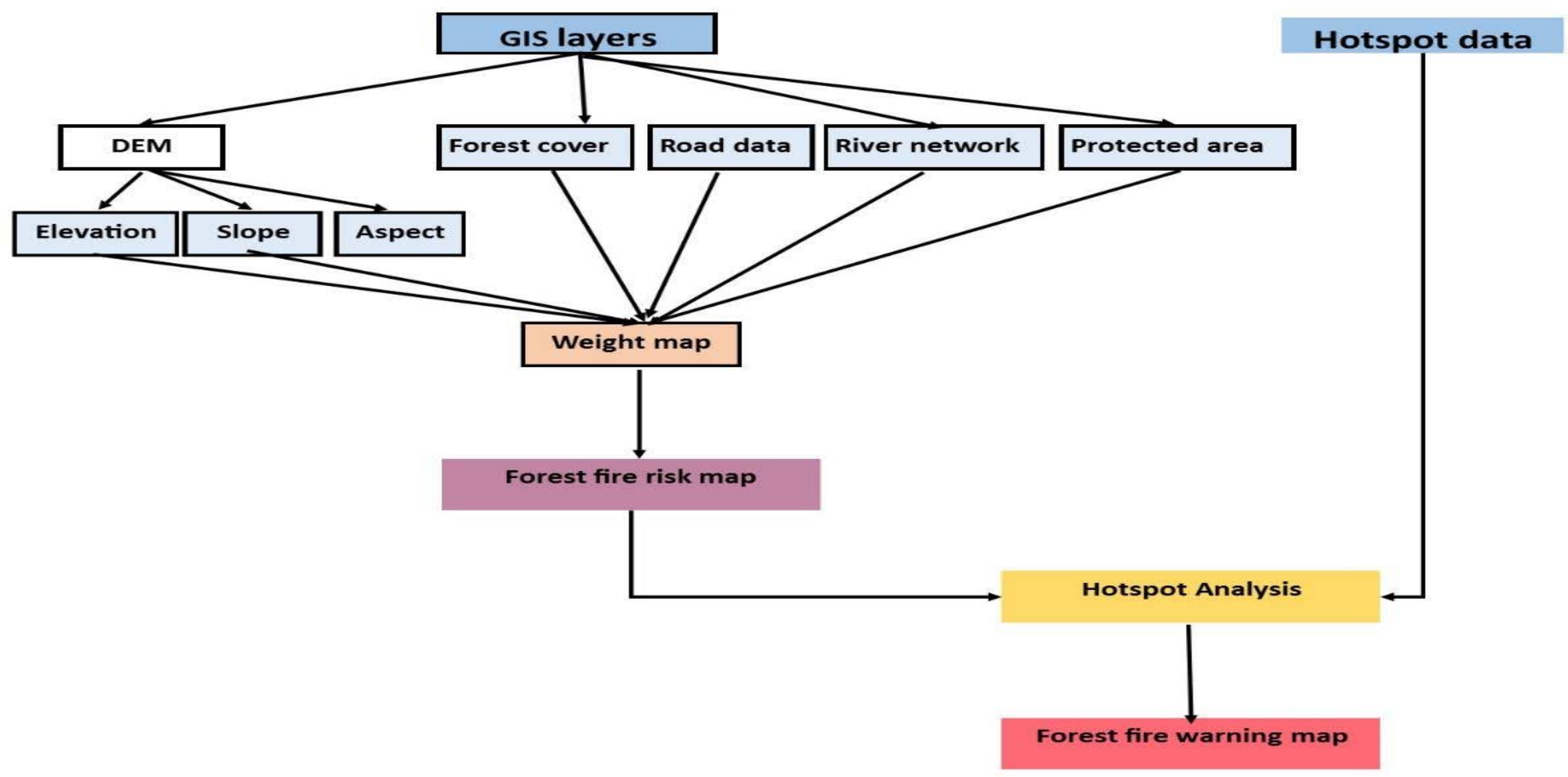
Source: Statistic from Firms (https://earthdata.nasa.gov/data/near-real-time-data/firms/active-fire-data)

ACTIVE FIRE OCCURRENCE IN THE NORTHWEST IN 2010





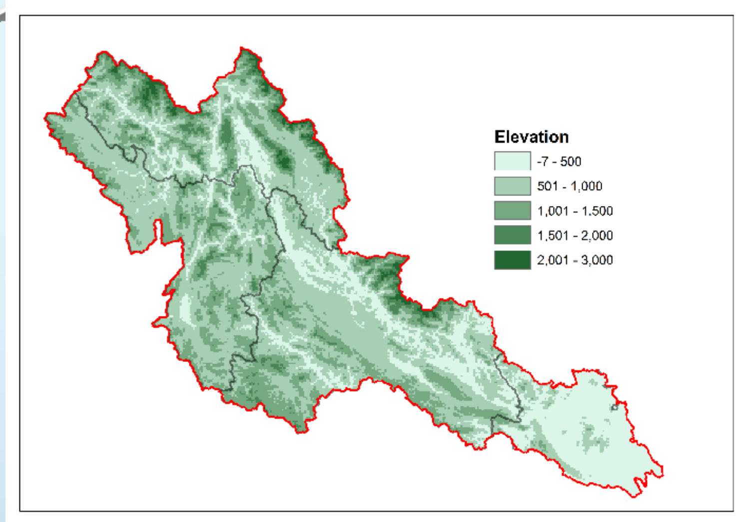
GENERAL APPROACH ADOPTED FOR STUDY



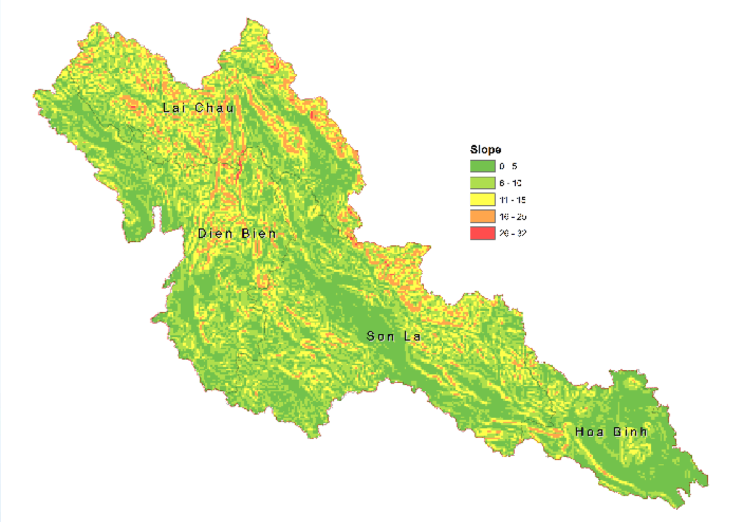
DATA USED

ID	Categories	Index	Source
1	Topography	Elevation	STRM 90m (http://www.cgiar-csi.org/data/srtm-90m-digital-elevation-database-v4-1).
2		Slope	Derived from Elevation data
3		Aspect	Derived from Elevation data
4		Hydrographic Network	Topographic data 1:1000000 from MONRE
5		Road Network	Topographic data 1:1000000 from MONRE
6	**Forest cover**	Land cover map	FIPI (2010)
7	**Protected area**	Protected area	FIPI (2010)
8	**Active fire data**	Active fire point	FIRMS (https://earthdata.nasa.gov/data/near-real-time-data/firms/active-fire-data).

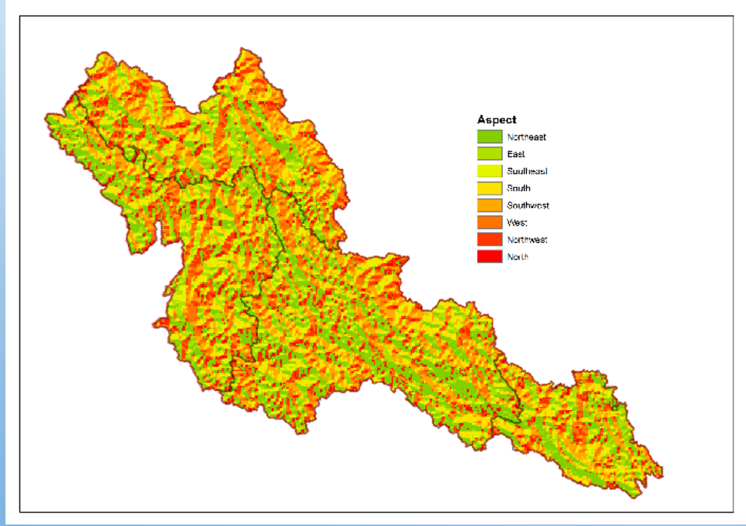
Input data



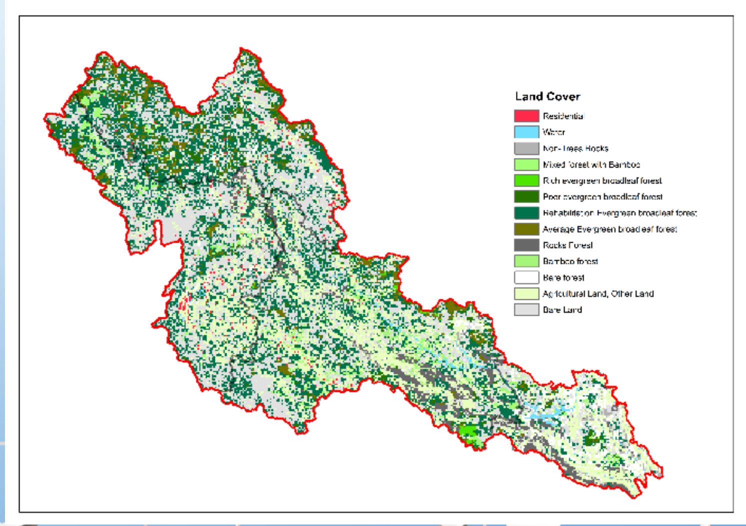
Elevation
-7 - 500
501 - 1,000
1,001 - 1,500
1,501 - 2,000
2,001 - 3,000



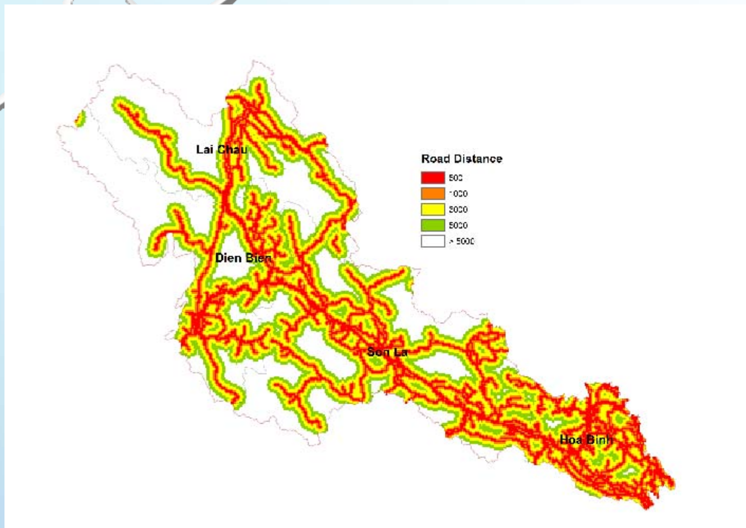
Lai Chau
Dien Bien
Son La
Hoa Binh
Slope
0 - 5
6 - 10
11 - 15
16 - 20
20 - 32

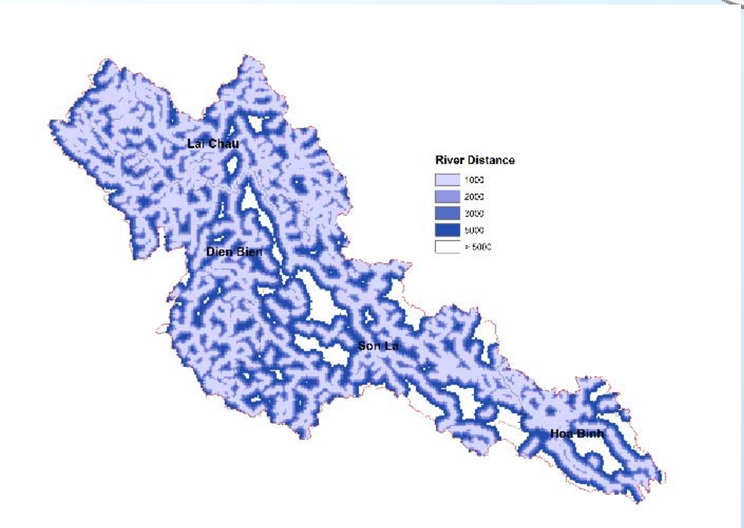


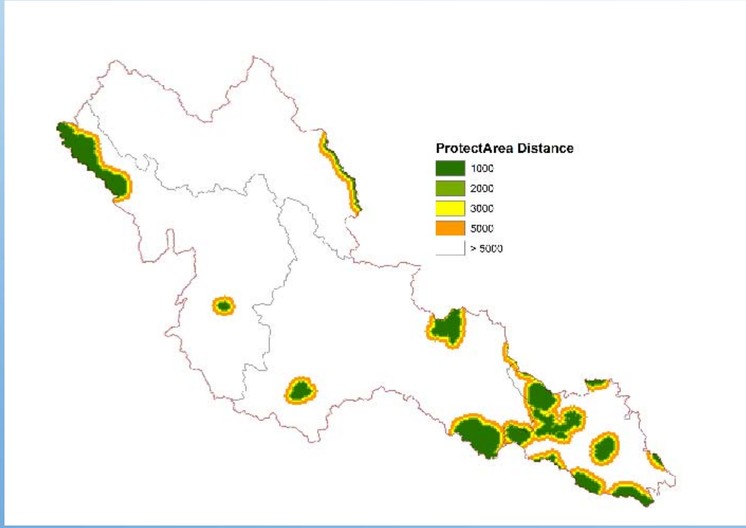
Aspect
Northeast
East
Southeast
South
Southwest
West
Northwest
North

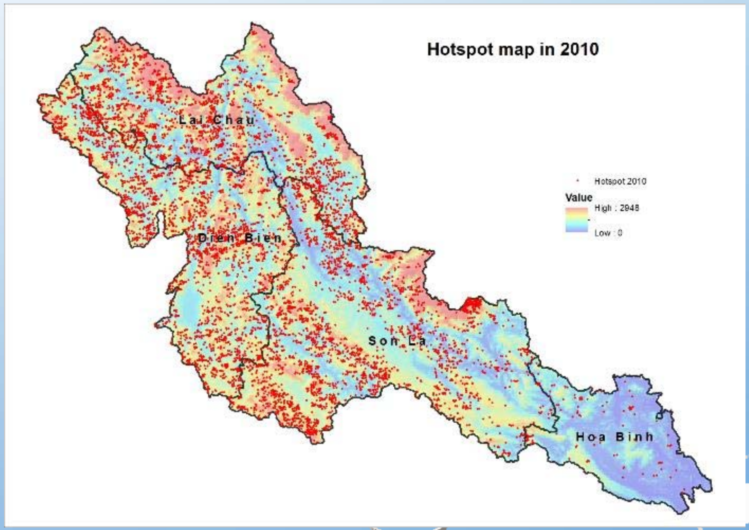


Land Cover
Residential
Water
Non-trees Rocks
Mixed forest with Bamboo
Rich evergreen broadleaf forest
Poor evergreen broadleaf forest
Rehabilitation Evergreen broadleaf forest
Average Evergreen broadleaf forest
Rocks Forest
Bamboo forest
Bare forest
Agricultural Land, Other Land
Bare Land


Road Distance
500
1000
3000
5000
> 5000
Lai Chau
Dien Bien
Son La
Hoa Binh


River Distance
1000
2000
3000
5000
> 5000
Lai Chau
Dien Bien
Son La
Hoa Binh


ProtectArea Distance
1000
2000
3000
5000
> 5000


Hotspot map in 2010
Hotspot 2010
Value
High : 2948
Low : 0
Lai Chau
Dien Bien
Son La
Hoa Binh

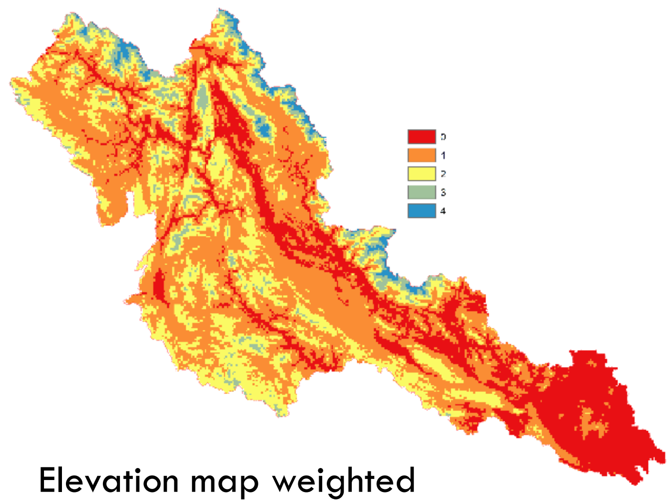
FIRE HAZARD MODEL WEIGHTED MAP

Forest cover (weight 100)				
ID	Land cover	Area(km2)	Coff	Fire_Rating
1	Agricultural Land	12708	1	High
2	Bare land	14384	4	Very low
3	Built-up	2187	3	Low
4	Water	1028	4	Very low
5	Bare rock	1146	4	Very low
6	Mix bamboo forest	587	2	Medium
7	Rich evergreen broad-leaf forest	36	2	Medium
8	Poor evergreen broad-leaf forest	1987	1	High
9	Rehabilitation evergreen broad-leaf forest	10159	1	High
10	Medium evergreen broad-leaf forest	861	1	High
11	Forest rock	1360	1	High
12	Plantation forest	2369	0	Very high
13	Bamboo forest	1327	1	High

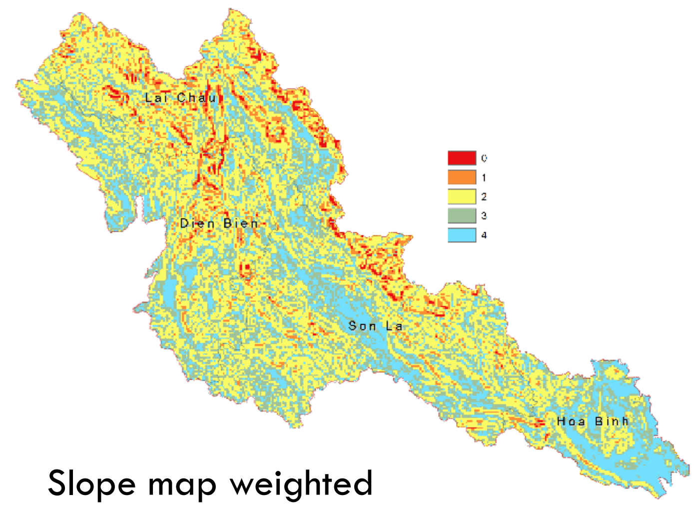
Slope (weight 30)		
Slope	**Coeff**	**Fire Rating**
> 35 %	3	low
35 - 25 %	1	High
25 - 10 %	0	Very high
10 - 5 %	2	Medium
< 5 %	4	Very low

Aspect (weight 10)		
ASPECT	**COEFF**	**Fire Rating**
North	1	High
Northeast	0	Very high
East	2	Medium
Southeast	3	Low
South	3	Low
South	1	High
Southwest	1	High
West	2	Medium
Northeast	4	Very low
North	4	Very low

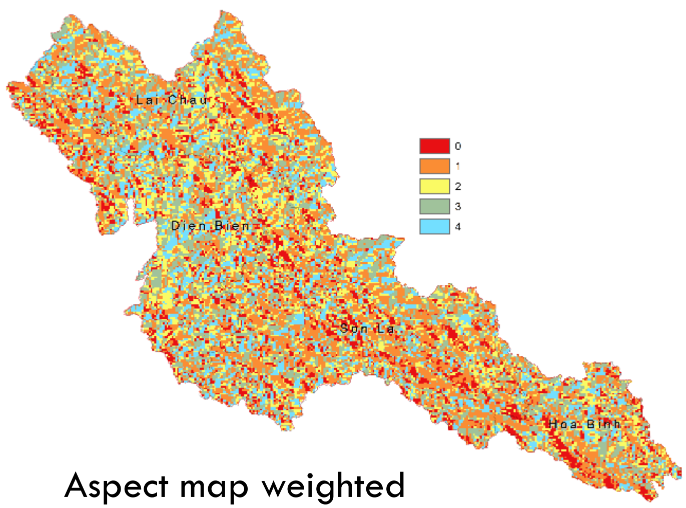
Weighted map



Elevation map weighted



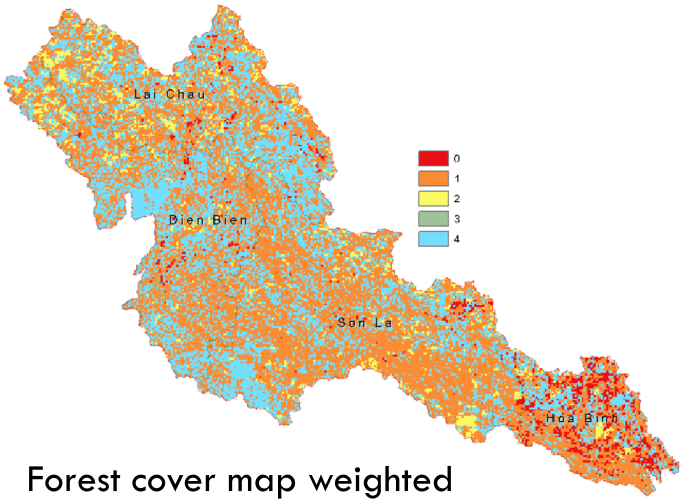
Slope map weighted



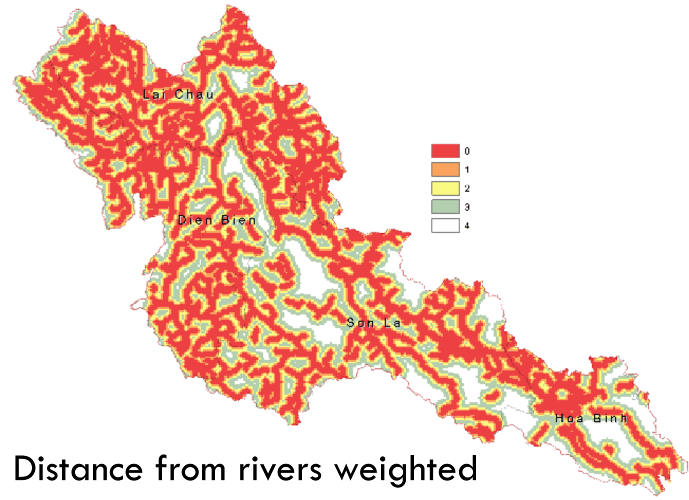
Aspect map weighted

Risk ranking:

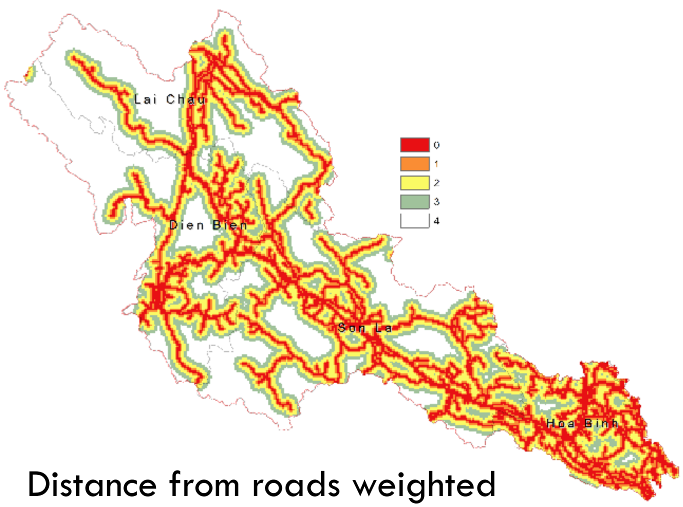
0. Very high
1. High
2. Medium
3. Low
4. Very low



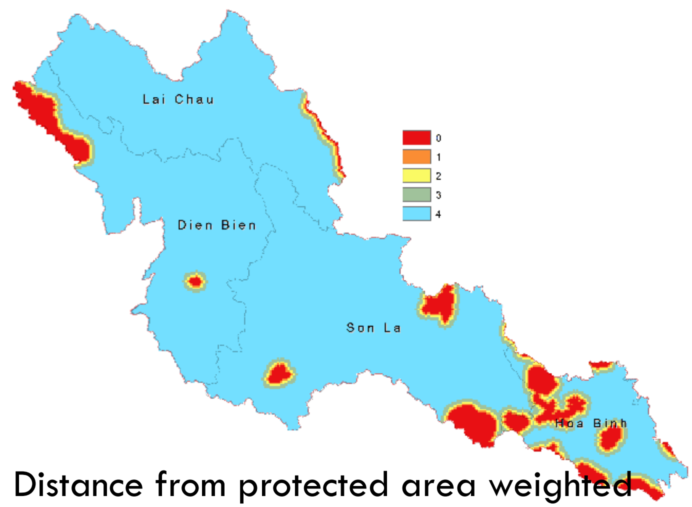
Forest cover map weighted



Distance from rivers weighted

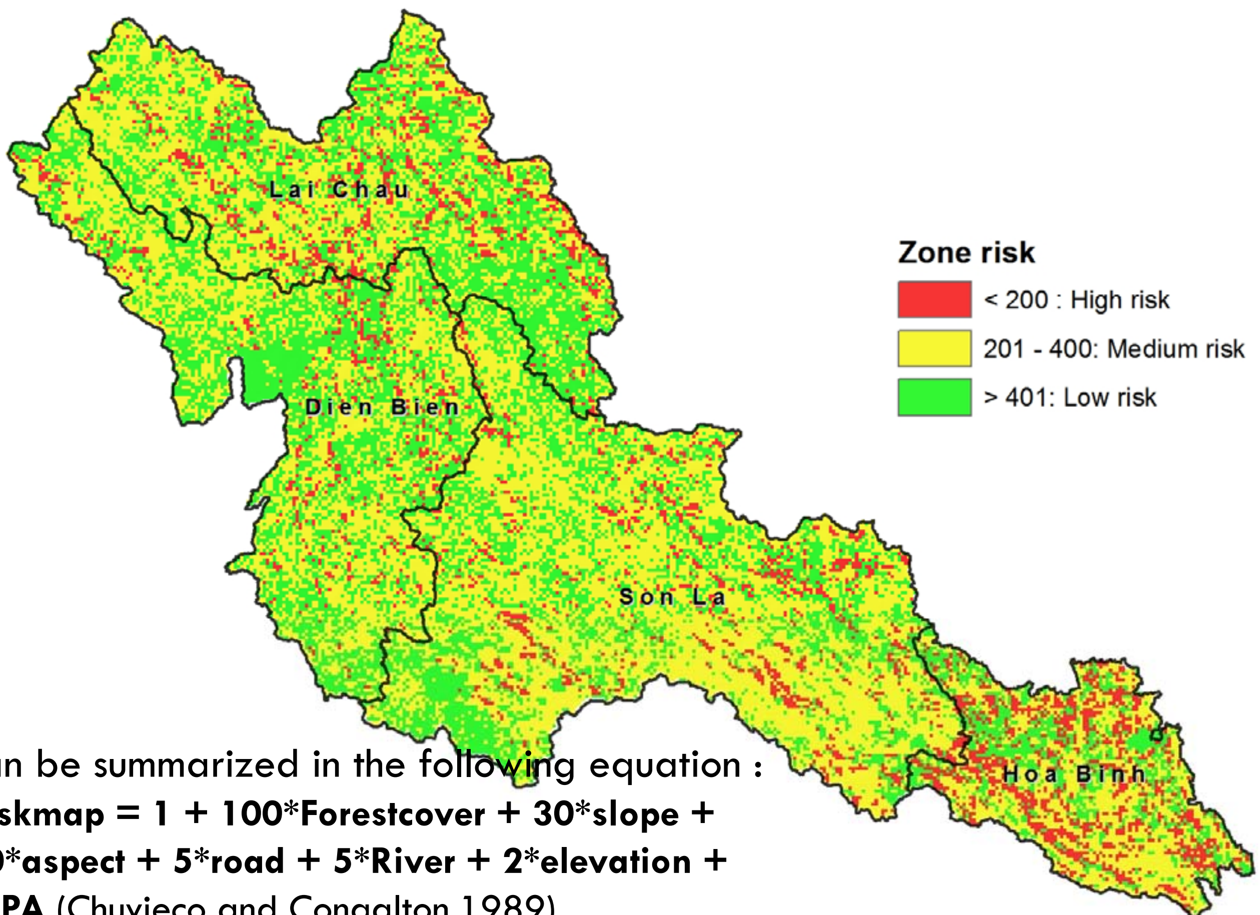


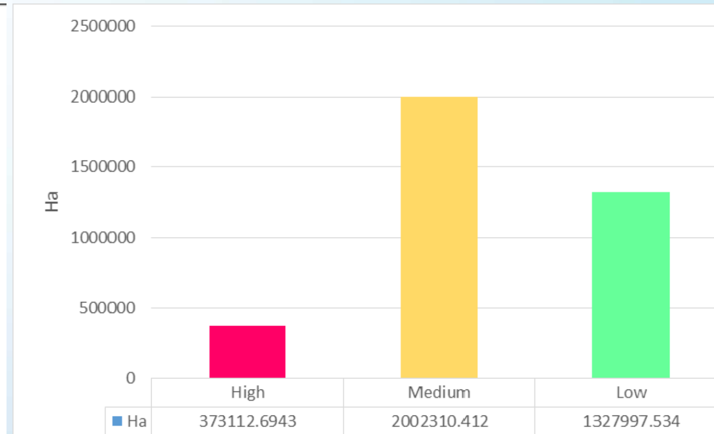
Distance from roads weighted



Distance from protected area weighted

THE FIRE RISK MAP





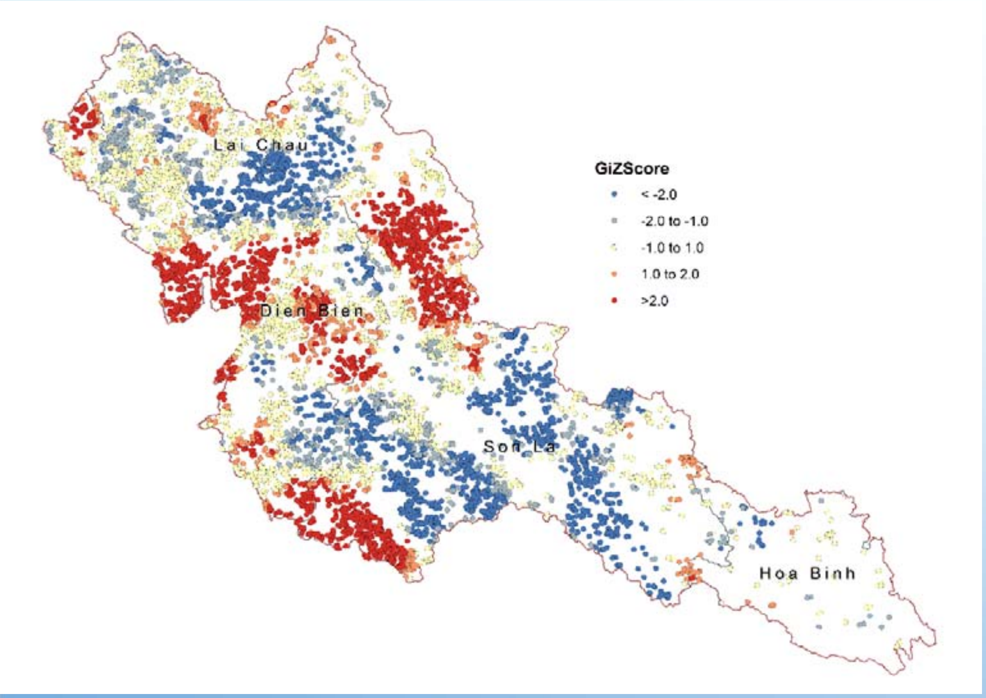
Fire risk	Ha	%
High	373112.7	10.07
Medium	2002310	54.07
Low	1327998	35.86
Total	3703421	100

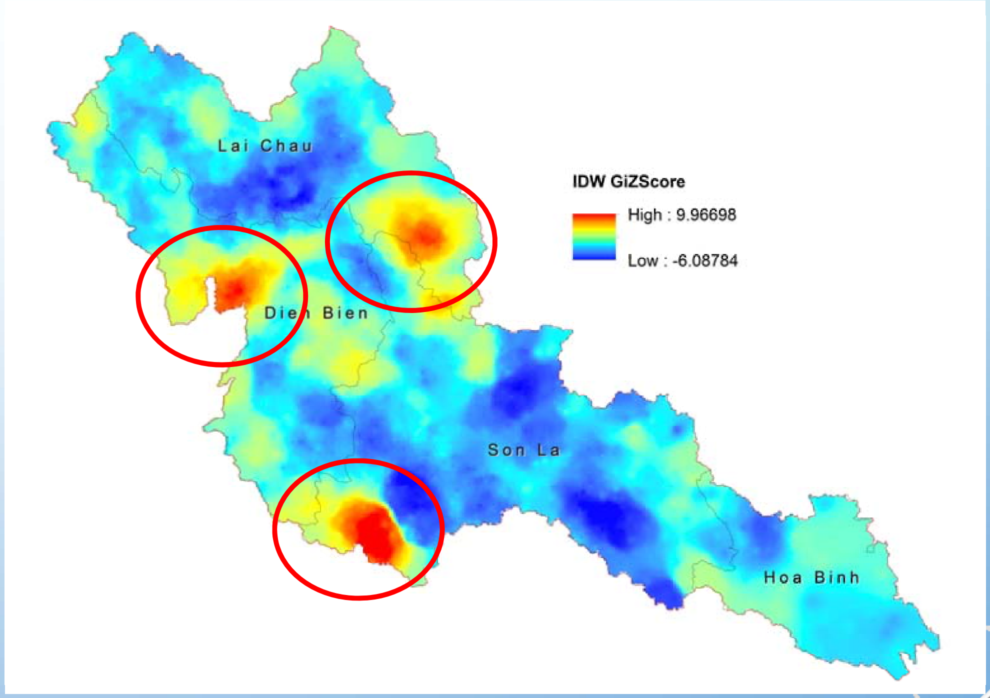
can be summarized in the following equation :
Riskmap = 1 + 100*Forestcover + 30*slope + 10*aspect + 5*road + 5*River + 2*elevation + 2*PA (Chuvieco and Congalton,1989)

THE HOT SPOT ANALYSIS

- THE HOT SPOT ANALYSIS TOOL CALCULATES THE GETIS-ORD GI* STATISTIC FOR EACH FEATURE IN A DATASET. THE RESULTANT Z-SCORES AND P-VALUES TELL YOU WHERE FEATURES WITH EITHER HIGH OR LOW VALUES CLUSTER SPATIALLY. THIS TOOL WORKS BY LOOKING AT EACH FEATURE WITHIN THE CONTEXT OF NEIGHBORING FEATURES. A FEATURE WITH A HIGH VALUE IS INTERESTING BUT MAY NOT BE A STATISTICALLY SIGNIFICANT HOT SPOT. TO BE A STATISTICALLY SIGNIFICANT HOT SPOT, A FEATURE WILL HAVE A HIGH VALUE AND BE SURROUNDED BY OTHER FEATURES WITH HIGH VALUES AS WELL. THE LOCAL SUM FOR A FEATURE AND ITS NEIGHBORS IS COMPARED PROPORTIONALLY TO THE SUM OF ALL FEATURES; WHEN THE LOCAL SUM IS VERY DIFFERENT FROM THE EXPECTED LOCAL SUM, AND THAT DIFFERENCE IS TOO LARGE TO BE THE RESULT OF RANDOM CHANCE, A STATISTICALLY SIGNIFICANT Z-SCORE RESULTS.
- DETERMINE HOW AND TO WHAT EXTENT COMMONLY KNOWN FIRE FACTORS CONTRIBUTE TO FIRE OCCURRENCES. THIS WAS EXAMINED USING THE SPATIAL STATISTICS HOT SPOT ANALYSIS TOOL FROM ARCGIS WHICH USES THE GETIS-ORD GI* ALGORITHM
- ACCORDING TO GETIS AND ORD, THE GI * STATISTIC IS USED TO MEASURE THE DEGREE OF ASSOCIATION FROM A CONCENTRATION OF WEIGHTED POINTS (GETIS, AND ORD, 1992). GREATER GI* VALUES INDICATE SIGNIFICANT SPATIAL CLUSTERING WITH VALUES >2 (POTTER, 2009). GREATER GI* VALUES INDICATE SIGNIFICANT SPATIAL CLUSTERING WITH VALUES >2 (POTTER, 2009). A TOTAL WEIGHTED FIELD CALCULATED FROM THE SIX LAYERS USED IN THE FIRE RISK MODEL WAS ADDED TO THE TOTAL FIRE RISK DATA. THIS NEW FIELD WAS USED AS THE INPUT FOR THE HOTSPOT ANALYSIS
- A STATISTICALLY SIGNIFICANT ($P < 0.05$) SPATIAL CLUSTERING. THIS INDICATES THESE AREAS HAD A HIGHER RISK THAN OTHER AREAS. DATA FROM THE RESULTING ANALYSIS WERE THEN INTERPOLATED USING AN INVERSE DISTANCE WEIGHTED (IDW) TECHNIQUE .THIS INDICATES THESE AREAS HAD A HIGHER RISK THAN OTHER AREAS. DATA FROM THE RESULTING ANALYSIS WERE THEN INTERPOLATED USING AN INVERSE DISTANCE WEIGHTED (IDW) TECHNIQUE .

HOTSPOT OF ACTIVE FIRE IN THE NORTHWEST IN 2010





CONCLUSION

- SPATIAL ANALYSIS WITH GIS USING DIFFERENT DATA ALLOW TO LOOK AT HOT SPOT FROM VARIOUS ANGLE OF VIEW (RELATING TO FIRE RISK)
- FROM THE TOTAL AREA OF 3.703.421 HA INCLUDED IN THIS STUDY, 10% OCCURRED IN AREAS OF HIGH HAZARD, 54% IN MEDIUM HAZARD AND 36% IN LOW HAZARD AREAS. USING HISTORICAL FIRE DATA, A CORRELATION BETWEEN SEVERAL VARIABLES AND RISK AREAS WAS DETERMINED.
- FURTHER RESEARCH SHOULD BE DEVOTED TO IDENTIFY THE DRIVING FORCES OF FACTORS OTHER THAN NATURAL CONDITIONS SUCH AS POPULATION DISTRIBUTION, LIVELIHOOD TYPES, LAND USE PRACTICE ETC.

ACKNOWLEDGEMENTS

THIS WORK WAS JOINTLY SUPPORTED BY THE PROJECTED: "INTEGRATION OF WEBGIS AND MULTIDATE AND MULTI RESOLUTION SATELLITE IMAGE PROCESSING TECHNOLOGIES FOR FOREST FIRE MONITORING IN VIETNAM" FUNDED VIETNAM NATIONAL UNIVERSITY, HANOI (2013 - 2015).

Thanks for your attention !