OPEN ACCESS INTERNATIONAL JOURNAL OF SCIENCE & ENGINEERING

ASSESSMENT OF TECHNIQUES FOR MODELLING FOREST FIRE RISK AND HAZARDS

Shruti Kanga

Assistant Professor, Centre for Climate Change and Water Research, Suresh Gyan Vihar University, Jaipur, India.

Abstract: Forest fires (rapidly spreading fires) have turned into a striking cause of worry for ecological specialists. Appraisal of flame impacts at nearby scale is progressively viewed as a basic part of biological community working, since flame assumes an essential part in vegetation organization, biodiversity, soil disintegration and the hydrological cycle. At worldwide scale, fire is the most summed up methods for changing tropical woodland in farming zones, and it impact sly affects worldwide air science. Fire is a characteristic factor in many atmospheres with elevated amounts of vegetation push. Though, changes in usual land utilize, for example, chasing, charcoal creation, wasteful logging exercises and regional dumping designs, which have been recognized as significant reasons for rapidly spreading fires, have as of late altered the rate of flame. A few appraisal procedures and techniques have been created to enable model and assess to forest fire hazard and risk. There is the need to recognize a strategy or blend of strategies to enable forest fire to hazard and danger models to empower the manageability of the characteristic assets. In this paper, the different techniques are reviewed with a specific end goal to upgrade the utilization of proper method(s) for forest fire hazard and danger management. From the survey and conclusions of the strategies, it was inferred that spatial multi-criteria displaying and assessment of fire hazard and risk is favoured. It was likewise derived that mix of spatial multi-criteria modelling with different techniques has ended up being more productive and compelling when contrasted and the utilization of individual strategies.

----------∴∴∴----------

I INTRODUCTION

Fire is a characteristic procedure in numerous biological systems that have a long history of flame unsettling influence. Most created nations have entrenched techniques and the physical and human foundation to complete fire concealment all together to secure lives and property 9Goldammer and Stocks, 2000; Ward and Mawdsley, 20000. Therefore, the fire administration in numerous biological systems has been changed. For instance, the concealment of some little, low-power fires has prompted a developing gathering of fuel, which have brought about bigger furthermore, more extreme flames over the long haul. Results from comparable examinations have demonstrated that fire approach should be checked on and a few nations are as of now utilizing recommended consuming to diminish fuel loads, or have embraced a "released them" strategy for flames that have regular causes [Grissom et al., 2000].

On the other hand, the same number of creating nations have not created the foundation for flame concealment, most flames are permitted to consume without intercession, despite the fact that they are for the most part human caused. (Kanga et al., 2017) Forest fire spread analysis and loss assessment using simulation modeling techniques. Knowledge of the factors which includes forest types, canopy cover, meteorological status, topographic feature accelerating forest fire were taken into considerations. The parameters derived from remote sensing data and Geographical Information System (GIS) were used to generate input files for forest fire simulation modeling using FARISTE.

Natural strategy requires the convenient era of solid data to help basic leadership. For flame administration, this data incorporates maps of (1) verifiable examples of flame starts, sources, and consumed region; (2) the area of structures, homes, streets, railways also, utility passages; (3) vegetation sort and fuel loads; (4) fuel condition, specifically the dampness substance of live what's more, dead vegetation; (5) geology; (6) the potential harm to the scene and human esteems coming about because of fire (e.g., fire weakness); and (7) the effects of the fire on vegetation regrowth, disintegration, and other natural attributes (related with consume seriousness). Moreover to the information itself, techniques are required to coordinate information from

different sources and give data in an opportune design. Directors require the methods and ways to deal with coordinate these data items into evaluations of fire hazard and likelihood. Kanga et al., 2013 have mapped Forest fire risk to tourist spots using Multi-Criteria Decision Analysis MCDA, Analytic Hierarchy Process AHP, and Fuzzy techniques.

Stolle and Lambin (2003) noticed that combustible fuel relies upon climatic conditions, soil, vegetation and past flame occasions. The start source is normal (for instance helping) or anthropogenic. In the event that the start source is anthropogenic, it can be caused purposely (as a component of land administration) or accidently through carelessness. Fire insights are somewhat poor in most fire-influenced nations. Most flames are georeferenced coarsely or not by any means, despite the fact that lately the developing utilization of worldwide situating framework (GPS) innovation has enhanced the circumstance in created nations. Quickly spreading fires affect situations clearly by angering competition relations between and inside species and by enlivening the carbon cycle, supplement cycle, hydrological cycle and imperativeness cycle (Thonicke et al., 2001). They in like manner impact situations by suggestion by advancing environment. Furious blasts bolster plants with specific regenerative and survival systems in different fire organizations Climate incited variety in backwoods fire in Bilaspur District of Himachal Pradesh were evaluated and LISS 3 and ASTER DEM has been utilized to recognize woods fire by overlaying topographical directions of weighted topical layers, for example, height, incline, perspective, mean yearly temperature, mugginess, wind speed, openness to home and settlement and fuel guide of the locale (Kanga et al., 2017).

II FIRE IDENTIFICATION AND OBSERVATION

Conventional ground-based visual identification strategies are not generally proper for offering solid data ablaze area, size and power because of the little field of view and regularly troublesome territory. Remote detecting has ended up being an important information source in various periods of flame administration both earlier (aversion) and after the fire (harm appraisal). Remote detecting perception has huge points of interest over regular fire location and fire observing strategies on account of its redundant and reliable scope over expansive regions of land (Martin et al., 1999). Fire produces four types of flag that are effortlessly seen from space (Robinson, 1991). These are quick radiation from dynamic flares (warmth and light), smoke, post-fire broil, and altered vegetative structure (scar). There are different satellites and carrier borne remote identifying structures which can add to fire seeing from space, including NOAA-AVHRR, Landsat-TM and MSS, SPOT, GOES, DMSP, ERS-ATSR, and JERS. The common, loathsome and spatial qualities of these instruments give a broad assortment of recognizing capacities and some of them have been gave off an impression of being all around changed in accordance with fire area application. NOAA-AVHRR and GOES have given whole deal operational systems, allowing negligible exertion organize assembling and close consistent fire information (Martin et al., 1999).

Satellite perception of dynamic flames depends on two distinctive physical standards. From one viewpoint, fire produces light, and in this way can be recognized on night time satellite symbolism utilizing the obvious wavelengths of the electromagnetic range (Elvidge, 2001). Since 2000, worldwide fire recognition has been incredibly enhanced the premise of information gathered by MODIS (Moderate determination Imaging Spectro radiometer). This sensor incorporates a few groups in the warm and center infrared that were particularly characterized for recognizing fire abnormalities, also, along these lines it gives higher precision than AVHRR information. Fire recognition depends on an arrangement of standards connected to various otherworldly groups, including relevant criteria (Giglio et al., 2006). Distinguished dynamic flames are recorded day by day and made openly available in the web through the MODIS.

Regardless of these challenges, analysts have conveyed out fuel sort mapping from medium and high-determination sensors, basically utilizing Landsat-TM and MSS information (Anderson et al., 1993; Fazakas et al., 1999). The outcomes were great (over 80% precision) for a few classes (grasses, thick woods, thick bush), however fizzled for those that require tallness estimations for separation. Radar and Lidar sensors give a conceivable option to the two troubles beforehand expressed. On one hand, L or C-band radar information may give extra data on the backwoods understory, on account of their covering infiltration capacity. Various examinations in view of ERS-1, JER-1 and Radarsat information have been embraced to foresee backwoods traits that are basic for fuel sort mapping, for example, foliar biomass, tree volume, tree stature and shade conclusion (Hyyppa et al., 2000). Reproduction displaying likewise gives a sufficient device to evaluate hazard when real hazard information are restricted or inaccessible (Kanga et al., 2014).

The uses of GIS to flame chance displaying have considered an extensive variety of danger factors, contingent upon the particular qualities of flame occasions in the diverse test locales. By the by it can be condensed into a few essential factors, for example, geology (height, slant, angle and brightening), vegetation (fuel sort, dampness content), climate designs (temperature, relative mugginess, wind and

precipitation), openness to streets and campgrounds, arrive property sort, separation to urban areas, soils, fire history and water accessibility. Accordingly, this paper tries to audit the different strategies that are being utilized to show and assess woodland fire hazard and danger keeping in mind the end goal to upgrade the fitting appropriation of method(s) for powerful and productive avoidance, control and finish end of rapidly spreading fires in the delicate biological community.

III PROCESSES OF FIRE RISK AND HAZARD MODELING

To demonstrate and assess fire hazard and danger, there is the requirement for appropriate fire chance evaluation. The accompanying segments take a gander at factors impacting fire conduct, the hazard survey techniques, displaying of flame hazard and risk strategies. The elements impacting fire conduct can either be regular or man-prompted. Fire lead is an entrancing term used to dole out what fire does and how it goes ahead. It gages what a fire will do and relates to power, fire and rate of spread of specific fire. A result of natural elements which connect with each different incorporates fuel, geology, climate and fire. The power and speed with which a fire wanders depends upon the entirety and course of action of the fine dead fuel, clamminess substance of the dead fuel, wind speed near the flaring zone, scene and inclination (Gould, 2005).

Pyne et al. (1996) exhibited the idea of the fire condition the encompassing conditions, impacts, and changing strengths that decide the conduct of a fire. Geography, fuel, atmosphere and the fire itself are the working together effects that make up the fire condition. This is appeared as a fire area triangle with the fire in the center. The changing states of each of the characteristic portions; fuel, topography and atmosphere and their association with each extraordinary and moreover the fire itself choose the properties and direct of a fire at any given moment. Changes in fire lead in space and time occur in association with changes in the biological parts. From a wild land fire position, geography does not change with time, but instead can contrast phenomenally in space. The fuel segment fluctuates in both space and time. Climate is the most factor segment, changing quickly in both space and time.

For temperature, higher height prompts bring down temperature, which likewise implies there will be bring down likelihood for flame to show up in higher rise zone. Both precipitation and temperature are influenced by tallness and the results for the forested areas fire are the same, so they can be seen as together. Tallness above sea level effects general environment and consequently impacts fuel availability. Length of fire season and fuel move with tallness in view of complexities in measure of precipitation got, snow break down dates, green up and curing dates (Chuvieco and Congalton 1989).

Height is a vital physiographic factor that is identified with wind conduct and subsequently influences fire inclination (Rothermel, 1993). Fire ventures most quickly up-incline and slightest quickly down-slant. For the most part, in the northern half of the globe, south and southwest perspectives are most ideal for flame to begin and spread. These zones get more sunlight and thus have cut down dampness and higher fuel temperatures (Pyne et al., 1996). Daylight based radiation drive is most noticeable when the inclination is inverse to the sun point. In the northern portion of the globe, controls on slants with an easterly edge will dry out earlier in the day, yet may not advance toward getting to be as dry as those on inclines with a westerly point of view (Pyne et al., 1996).

It can be concluded that the slant which confronts the breeze course is less demanding to cause seething flame. A north-bound incline likewise gets less daylight than a south-bound slant. In this way, Southern points of view get more direct warmth from the sun, drying both the earth and the vegetation. Incline is a basic factor among topographic factors. Slope to a great extent influences the speed of fire when it is spreading. Kushla and Ripple (1998), say that fire constantly spreads speedier up-slant than down-incline. Incline steepness in like manner impacts the radiation power and fuel moistness. The grades where the fuel will be the driest vary with time of year, time of day, and extension. As needs be, as a fire moves over the scene its direct can be depended upon to change with time of day and topographic characteristics in perspective of the assortments accomplished by the particular aggregates and drive of the sun based radiation got (Pyne et al., 1996.

Vegetation sort has a solid association with the woodland fire chance. Diverse sorts of vegetation have various types of instability. By and large, a coniferous wood has a higher likelihood for flame hazard than deciduous woodland, in light of the fact that coniferous trees contain less water and higher sleekness (Li, 1998). Fuel is a basic leg in both of the fire triangles: fuel, oxygen, and warmth of the fire basic triangle; and additionally fuel, geology and climate of the fire condition triangle. Fuel does not cause fire, but rather it positively changes the character of a fire, influencing the simplicity of start and fire size and force (Pyne et al., 1996).

Fuel state alludes to the dampness substance of the fuel and whether it is alive or dead. Fuel sort is a depiction of the fuel itself. The portrayal of fuel sort incorporates physical properties of fuel, fuel segment and fuel edifices. Fuel properties that influence the way the material consumes

incorporate amount, size, minimization and course of action. Fuel edifices, which are relationship of parts incorporate grass and timber with grass and litter understory (Pyne et al., 1996). Dampness content, communicated as a part, is the mass of water held by unit mass of stove dry fuel and is resolved principally by fuel sort and climate. It might likewise be communicated as a rate of the fuel stove dry weight. Fuel dampness is typically communicated on a dry issue premise and is a basic factor in deciding the power of a fire since it influences the simplicity of start, the amount of fuel devoured and the ignition rate of the distinctive sorts of fuel. The most critical impact of fuel dampness ablaze conduct is the covering impact of the water vapour discharged from the copying fuel.

It diminishes the measure of oxygen in the quick closeness of the consuming plant material hence diminishing the rate of burning. Fuel stack is viewed as a standout amongst the most imperative variables affecting flame conduct in light of the fact that the aggregate sum of warmth vitality accessible for discharge amid a fire is identified with the amount of fuel. Accepting a consistent warmth yield, the power of a fire is straightforwardly relative to the measure of fuel accessible for burning at any given rate of spread of the fire front.

IV HAZARD ASSESSMENT TECHNIQUES

Fire chance evaluation ought to be viewed as a particular piece of a more extensive, generally speaking, appraisal of the hazard to which the biological system is uncovered and might be a piece of a general program of hazard lessening. There are three sections to flame hazard evaluation: This includes the distinguishing proof of the risks and measuring the dangers. After recognizable proof of the risk, one vital thing is to choose whether the peril from flame is sufficiently essential to be a wellspring of genuine potential mischief or in any given circumstance may cause misfortune, demise, damage or harm. Thought is made on how likely it is that each peril could cause hurt. This will decide if there is the need to accomplish more to lessen the hazard. Indeed, even after the sum total of what safety measures have been taken, some hazard typically remains. A choice is made for each critical danger whether the rest of the hazard requires any control measures. Having made the underlying evaluation there takes after the critical errand of decreasing the dangers and dangers.

It will more likely than not be the situation that a few diminishments might be affected instantly, and these transient measures would incorporate such things as enhancing the natural practices-the administration of waste and refuse, and the execution of a program of terminate wellbeing preparing for representatives and group individuals. Other long haul measures would incorporate such things as the establishment of a fire concealment framework, the adjustment in some negative convictions and the substitution of dangerous procedures and materials with less unsafe ones. At the point when the dangers and dangers have been diminished to what, at the time, seems, by all accounts, to be a final level, there takes after a more thorough last appraisal of the hazard.

The last evaluation will decide the hazard categorization which routinely will be characterized as high, typical or low. Obviously in bigger premises, for example, a woods, it will be very typical to have diverse hazard classifications for various parts of the territory. The last appraisal will have three results: It will decide if the regions, or parts of it, are to be classified as being of high, typical, or generally safe; this thus will decide the fire careful steps required in the range, and it will be the beginning stage in the definition of a crisis design. In doing the hazard appraisal it will be important to have at the top of the priority list however not restricted to the accompanying variables: the living things exhibit in the region, the utilization to which the territory is put, the wellsprings of start display, the utilization of combustible materials, the substance of the region, the basic elements of the range, conventional convictions of the general population in the zone and fire training level in the zone.

Hazard evaluation methods give a profitable apparatus in endeavoring to arrange the degree and seriousness of hazard to which an association, country or the biological system may be at risk. While no technique is trustworthy, sensible utilization of hazard appraisal and use of the lessons attracted can come about more savvy presentation of flame defensive measures. There is no single "right" method for completing danger evaluation, there are three strategies which may be valuable, each of which clarifies what is to be comprehended by the terms high, ordinary and generally safe. These are:

The hazard classification marker technique: This is a demonstrative strategy in which the different components in the range are grouped so as to show the region in which they are found and ought to be sorted as being high, typical, or okay. Components which may offer ascend to high hazard pointers on account of backwoods include: groups; vegetation; wind; geography; street system; and negative conventional convictions.

The hazard esteem lattice strategy: Contrasting the risk category indicator technique, this technique endeavours to put the hazard appraisal onto a quantitative premise. Notwithstanding, it can't be unequivocally focused on that the numbers included are simply relative, and in this manner they

have no outright centrality at all. While all dangers are comprised of two components the likelihood that an occasion will occur and the outcomes of that event, the relative commitments of these two components to hazard may fluctuate impressively. The extent of the hazard esteem at that point turns into the reason for ordering the range as being of high, typical or generally safe.

V MULTI-CRITERIA ASSESSMENT FOR FOREST FIRE RISK MODELING

The physical premise to evaluate fire chance has numerous likenesses in the distinctive biological communities, the real definition differs starting with one nation then onto the next, and in this way an incredible assorted qualities of records is accessible since a considerable lot of them have been produced fundamentally for particular geographic range (Marzano et al., 2005). Long haul estimation tends to the general, more changeless, arranging of putting out fires assets, which is identified with the more auxiliary factors that influence fire start or fire engendering, for example, geology or territory characteristics, vegetation structure, human exercises or climate designs. These variables can be viewed as steady in any event amid an entire fire season; in this manner they don't should be refreshed much of the time. One quantitative way to deal with acquire a fire hazard record is to compute the weights of the diverse factors utilizing relapse investigation strategies, for example, calculated relapse. With regards to flame chance appraisal, fire event (typically communicated as number of start focuses/regions or as an extent of consumed range) is the reliant variable, while fire peril factors (slant, powers, fuel dampness, street organize, recreational regions, and so forth.) are the autonomous ones. Kanga et al., 2011, Mapping of forest fire susceptibility using knowledge based GIS modeling techniques for various factors has been done.

Multi-criteria assessment (MCE) is a basic leadership device created for complex multi-criteria issues that incorporate subjective or potentially quantitative parts of the issue in the basic leadership prepare (Mendoza et al., 1999). The MCE procedures (Chuvieco et al., 1999) might be a decent contrasting option to lessen the subjectivity of this doling out process, since the conclusion of specialists might be quantitatively evaluated. Additionally, every master's assessment might be weighted by his/her level of information in the field of study. The MCE systems have been utilized for flame peril mapping, weighting every threat variable after the master's assessment in two unique situations (Chuvieco et al., 1999). Multi-criteria investigation can be actualized utilizing expository chain of command prepare (AHP) (Saaty, 1980). The AHP technique approaches basic leadership by organizing the vital parts of an issue into a progressive structure like a family tree. The AHP technique decreases complex choices into a progression of straightforward correlations, called pairwise compari-children, between components of the choice chain of command. By combining the consequences of these correlations, AHP can give the best choice and give a reasonable method of reasoning to the decision (Mendoza et al., 1999). Sharma et al., 2012, have applied knowledge based and analytic hierarchy process (AHP) techniques. Knowledge-based criteria involve topographic and different themes for risk assessment. The assignment of value given to equation is significant due to its importance.

Choice criteria are formally assessed and distributed a score based convey inside the basic leadership handle. In many occurrences this procedure is accomplished utilizing multi-criteria assessment (MCE). The criteria considered in meaning of potential fire peril are incline, perspective, vegetation and groups". An exhaustive thought for flame hazard infers considering an extensive variety of factors. A typical terminology recognizes the ideas of hazard related with the start of a (fire start hazard or combustibility) and to the spreading of a dynamic (fire conduct hazard or fire danger).

For each situation, distinctive factors and diverse hazard weights ought to be considered. Be that as it may, both methodologies require being fit for coordinating diverse spatial factors. GIS gives instruments to on master sentiment in regards to the weight every criteria will make, change and consolidate geo-referenced factors. In this way, GIS can spatially coordinate a few danger factors identified with flame hazard and give devices to chance examination (Chuvieco et al., 1999). The utilizations of GIS to flame chance demonstrating have considered an extensive variety of peril factors, contingent upon the particular qualities of flame occasions in the distinctive test destinations.

VI INTEGRATED SPATIAL MULTI-CRITERIA METHODS FOR FIRE RISK AND HAZARD MODELLING

This method combines two or more methods to help in decision analysis of optimal model for fire risk and hazard. Decision analysis is a set of systematic procedures for analysing complex decision problems. These procedures include dividing the decision problems into smaller and more understandable parts; analysing each part, and integrating the parts in a logical manner to produce a meaningful solution (Malczewski, 1999). In general, multi- criteria decision analysis (MCDA) problems involve six components (Keeney and Raiffa, 1976; Pitz and McKillip, 1984). MCDA techniques can be used to identify a single most preferred option, to rank options, to list a limited number of options for

subsequent detailed evaluation, or to distinguish acceptable from unacceptable possibilities. There are many MCDA approaches which differ in how they combine and utilize the data. MCDA approaches can be classified on the basis of the major components of multi-criteria decision analysis. Three different classifications can be made. These are 1. Multi-objective decision making (MODM) versus multi- attribute decision making (MADM); 2. Individual versus group decision maker problems; and 3. Decisions under certainty versus decisions under uncertainty. (Kanga et al., 2011; Kanga et al., 2017) Multi criteria analysis and weighed sum method base on knowledge based was used to map forest fire risk index map to minimize and manage the frequent forest fire incidents and damages.

The distinction between MADM and MODM is based on the evaluation criteria which are the standards of judgments or rules on which the alternatives are ranked according to their desirability. Criterion is a general term and includes both the concepts of attributes and objectives. An attribute is a measurable quantity whose value reflects the degree to which a particular objective is achieved. An objective is a statement about the desired state of the system under consideration (Chankong and Haimes, 1983). It indicates the directions of improvement of one or more attributes. Objectives are functionality related, or derived from a set of attributes (Malczewski, 1999). There might be formal relationship between objectives and attributes, but usually the relationship is informal. To assign an attribute to a given objective, two properties, which are comprehensiveness and measurability, should be satisfied. An attribute is comprehensive if its value sufficiently indicates the degree to which the objective is met. And it is measurable if it is reasonably practical to assign a value in a relevant measurement scale.

The ratio, interval, ordinal and binary scales are suitable for measuring attributes, whereas nominal scale is not since it does not allow an ordering of the alternatives (Janssen, 1992). MADM problems require that choices be made among alternatives described by their attributes. The set of attributes is given explicitly and multi-attribute problems have a finite set of feasible alternatives. Unlike MADM, MODM problems require that means-ends relationships be specified, since they deal explicitly with the relationship of attributes of alternatives to higher level objectives. MODM involves designing the alternatives and searching for the best decisions among an infinite or very large set of feasible alternatives. Each alternative is defined implicitly in terms of the decision variables and evaluated by means of objective functions (Malczewski, 1999).

Both MADM and MODM problems can be further classified as individual and group decision making depending on the goal-preference structure. If there is a single goal preference, the problem, is considered as individual decision-making regardless of the number of decision makers involved in the process. However, if the individual or interest groups are characterized by different goal preferences, the problem becomes the group decision making (Malczewski, 1999).

The other classification depends on the certainty of the decision. If the decision maker has perfect knowledge of the decision environment and the amount of knowledge available is enough, then the decision is considered as decision under certainty. However, most of the real world decisions involve some aspects that are unknown and difficult to predict. This type of decisions is referred to as decisions under uncertainty. The decisions under uncertainty can be further subdivided into fuzzy and probabilistic decision making (Eastman et al., 1993). The probabilistic decisions are handled by probability theory and statistics; and the outcome of a stochastic event is either true or false. However, if the situation is ambiguous, the problem is structured as the degree of how much an event belongs to a class. This type of problems is handled by fuzzy set theory (Zadeh, 1965).

VII CONCLUSION

The utilization of GIS and RS advances has enhanced tremendously for the accumulation, accessibility of information, and coordinated administration of spatial and non-spatial information for woodland fire hazard and peril administration. The fire hazard and danger show produced from singular techniques does not have the one stop answer for backwoods fire administration. Thus, the requirement for the reception of an incorporated spatial multi-criteria ways to deal with flame hazard and danger demonstrating and assessment. Notwithstanding the current increment of logical managing with remote detecting and fire-related points because of imperative of research toward this path, there are as yet few operational frameworks that utilization routinely remotely detected information in any of the three periods of flame administration: estimation of fire risk conditions, distinguishing dynamic flames and surveying post fire impacts.

This reality might be caused by the absence of satellite missions situated toward the fire group or the adolescence of some estimation approaches. The previous is clear in the fire concealment stage, since none of the current Earth watching frameworks gives enough spatial what's more, fleeting determination for operational fire recognition. The last is clear in some basic fire items, for example, fuel sort maps that require extra endeavours to give exact estimations of fuel spatial changeability.

A recent advance in picture preparing of medium and low-determination satellite information makes it conceivable to anticipate the operational utilization of those information closes. This is the situation, for example of the consume scar mapping, which is as of now embraced in a few nations. Segregation of consume seriousness requires more research, to handle the distinctive impacts of flame harms on post fire reflectance, particularly when woodland is stratified in various vertical layers. Water substance of energizes is additionally near being operationally evaluated, albeit more issues are relied upon when water should be registered as an element of dry weight and not of leaf territory. The developing accessibility of information from new sensors, for example, Lidar or interferometric radar may likewise take care of the present issues with fuel sort maps. Most fire researchers perceive the need of something beyond refreshed and more precise spatial data to move forward current choices for pre fire arranging and post fire relief. New Earth Observation missions should handle current specialized constraints of accessible sensors on the off chance that we plan to utilize remotely detected information operationally. Moreover, we ought to keep up the exertion of giving approved items that are appropriately incorporated with different wellsprings of data for extensive fire hazard and fire impacts appraisal.

REFERENCES

[1] Anderson, G.L., J.D. Hanson, and R.J. Haas (1993). Evaluating Landsat Thematic Mapper derived vegetation indices for estimating above ground biomass on semiarid rangelands. *Remote Sens. Environ.*, 45(2), 165-175.

[2] Chankong V., and Haimes Y.Y. 1983. Multi Objective Decision Making: Theory and Methodology, North Holland Publishers, New York. pp. 350-400.

[3] Chuvieco, E., Congolton, R.G., 1999. Application of Remote Sensing and Geographical Information Systems to Forest Fire Hazard Mapping. Remote Sensing of Environment, Vol. 29, pp.147-159.

[4] Eastman J. R., Jin W., Kyem PAK, Toledano J. 1993. Raster Procedures for Multi-Criteria/Multi-objective Decisions. Photogramm. Eng. Remote Sens. 61 (5):539-547.

[5] Elvidge, C.D. (2001). DMSP-OLS estimation of Tropical forest area impacted by surface fires in Roraima, Brazil: 1995 versus 1998, *Int. J. Remote Sens.*, 22(14), 2661-2673.

[6] Fazakas Z., M. Nilsson, and H. Olsson. (1999). Regional forest biomass and wood volume estimation using satellite data and ancillary data, *Agric. For. Meteorol.*, 17,419-424.

[7] Giglio, L., I. A. Csiszar, and C.O. Justice (2006). Global distribution and seasonality of active fires as observed with the Terra and Aqua Moderate Resolution Imaging Spectrometer (MODIS) sensors, *J. Geophys. Res., III.* G02016. Doi:10.1029/2005JG000142.

[8] Goldammer, J. G., and B. J. Stocks (2000), Eurasian perspective of fire: Dimension, management, policies, and scientific requirements, in Fire, Climate Change, and Carbon Cycling in the Boreal Forest, edited by E. S. Kasischke and B. J. Stocks, pp. 49–65, Springer, New York.

[9] Gould J. (2005). Fire Danger and Fire Behaviour, Australia Overview International Fire Weather Workshop, Bureau of Meteorology, Melbourne. 24th November, 2010. 4-25.

[10] Grissom, P., et al. (2000), Effects of climate change on management and policy: Mitigation options in the North American boreal forest, in Fire, Climate Change, and Carbon Cycling in the Boreal Forest, edited by E. S. Kasischke and B. J. Stocks, pp. 85–101, Springer, New York.

[11] Hyyppa J. H., Hyyppa M. Inknen, M. Engdahl, S. Linko and Y. H. Zhu (2000). Accuracy comparison of various remote sensing data sources in the retrieval of forest stand attributes. *For. Ecol. Manage.*, 128 (1-2), 109-120.

[12] Janssen R. 1992. Multi-objective Decision Support for Environmental Management, Kluwer Academic, Dordrecht. p. 232.

[13] Kanga S., and Singh S. K. 2017. Forest Fire Simulation Modeling using Remote Sensing & GIS. International Journal of Advanced Research in Computer Science. 8 (5): 326-332.

[14] Kanga S., Kumar S., and Singh S. K. 2017. Climate induced variation in forest fire using Remote Sensing and GIS in Bilaspur District of Himachal Pradesh. International Journal of Engineering and Computer Science. 6 (6): 21695-21702.

[15] Kanga S., Tripathi G., and Singh S. K. 2017. Forest Fire Hazards Vulnerability and Risk Assessment in Bhajji Forest Range of Himachal Pradesh (India): A Geospatial Approach. Journal of Remote Sensing & GIS. 8 (1): 25-40.

[16] Kanga, S.K., L. K. Sharma, M. S. Nathawat, and Sharma S. K. 2011. Geospatial Approach for Forest Fire Risk Modeling: A Case Study of Taradevi Range of Shimla Forest Division in Himachal Pradesh, India. 137 (3):296.

[17] Kanga, S.K., L. K. Sharma, P. C. Pandey, and M. S. Nathawat. 2014. GIS Modeling for Forest Fire Risk Assessment and Management. International Journal of Advancement in Remote Sensing, GIS and Geography. 02 (1):30-44.

[18] Kanga, S.K., L. K. Sharma, P. C. Pandey, M. S. Nathawat, and Sinha S. 2011. Forest Fire Susceptibility Mapping with GIS Modeling. International Journal of Earth Sciences and Engineering. 04 (3):80-87.

[19] Kanga, S.K., P. C. Pandey, L. K. Sharma, M. S. Nathawat and Sharma S. K. 2013. Forest Fire Modeling to

evaluate potential hazard to tourism sites using geospatial approach. Journal of Geomatics. 07 (1):93-99.
[20] Keeney R. L. and Raiffa H. 1976. Decisions with Multiple Objectives: Preferences and Value Tradeoffs, Wiley, New York. 1993-569.
[21] Kushla JD, Ripple WJ (1998) Assessing wildfire effects with Landsat Thematic Mapper data. International Journal of Remote Sensing.
[22] Li T. (1998). Forest Fire Influencing Factors ant Types. J. Chin. Peoples Armed Police Force Acad. 4 31-33.
[23] Malczewski, J., 1999. GIS and Multi-criteria decision analysis, John Wiley and Sons Inc. NJ, USA. pp. 390.
[24] Martin M.P., Ceccato P., Flasse S., Downey I (1999). Fire Detection and Fire Growth Monitoring using Satellite Data, In: Chuvieco E (ed), Remote Sensing of Large Wildfires in the European Mediterranean Basin, Springer, Berlin, Germany. Pp. 101-122.
[25] Marzano, R., Bovio, B., Guglielmet, E., Jappiot, M., Lampin, C., Dauriac, F., Deshayes, M., Salas, J., Aguado, I., Martinez, J., Molina, D., Martinez, E., Carrega, P., Fox, D., Berolo, W., Martin, P., Gomes, I., Conese, C., Bonora, L., Karteris, M., Gitas, I., Mallinis, G., Giannakopoulos, V., 2005. Common methods for mapping the wildland fire danger. EUFIRELAB. Available at: http://eufirelab.org
[26] Mendoza G.A., Macoun P., Prabhu R., Sukadri D., Purnomo H., Hartanto H. 1999. Guidelines for Applying Multi Criteria Analysis to the Assessment of Criteria and Indicators, Criteria and Indicators Toolbox Series (9), CIFOR, Bagor, Indonesia. Pp. 15-70.
[27] Pitz G.F. and McKillip J. 1984. Decision Analysis for Program Evaluations, Thousand Oaks, CA: Sage Publications. Pp.327-287.
[28] Pyne S. J., Andrews P. L., Laven R. D. (1996). Introduction to Wildland Fire, John Wileys and Sons Inc.1:221-227.
[29] Robinson J. M., (1991). Problems in Global Fire Evaluation: Is Remote Sensing the Solution? In Levine J.S. (ed.), Global Biomass Burning: Atmospheric, Climatic and Biosheric Implications, MIIT Press, Cambridge, MA. Pp. 67-73.
[30] Rothermel, R. C., 1993. Some fire behavior modeling concepts for fire management systems. 12th Conference on Fire and Meteorology: Fire, Meteorology, and the Landscape, Jekyll Island, GA, 26-28 October.
[31] Saaty, L.T., 1980. The Analytic Hierarchy Process, New York, McGraw-Hill International.
[32] Sharma, L. K., Kanga, S. K., Nathawat, M. S., Sinha, S., and Pandey P. C. 2012. Fuzzy AHP for forest fire risk modelling. Disaster Prevention and Management. 21 (2): 160-171.