A natural resources conservation conceptual model in forest areas

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Abstract

Evaluation of environmental acts of Iran highlights the gap that soil conservation and impacts of deforestation and guidelines for stockholders of forest areas have not been presented properly. Therefore, this research aimed to develop a conceptual model for stating the problems raised by deforestation, to present practical approaches, and to define conservation levels to achieve sustainable land uses. The model method is designated stepwise to estimate impacts of deforestation, to find road map of management practices in terms of thematic and spatial planning for forest watersheds. We emphasize on application of nuclear techniques to estimate on-site and off-site effects of deforestation. The model outcome is framework of management practices in which levels of conservation, protection and preservation will be implemented. Conservation as the lowest level authorizes stockholders to the wood harvest and specific land uses with regarding to environmental considerations. Framework emphasize on criteria by which all present and programmed land uses should be compatible with the forest watershed ecological capabilities. In protection level, this model guides locals and authorized companies to carry out restoration and revitalization practices as buffer zone of preservation level. The conceptual model presents the preservation level in forest watersheds to keep untouched bio heritages (flora and fauna) through the forest breathing and technical supports in terms of research and production of plants. The practical road map as main outcome of the conceptual model guides decision makers around the world to reach sustainable plan of conservation and land use in watershed scale with considering human demands.

Introduction

Countless importance of forestry areas in terms of habitats for biodiversity and livelihood for humans, job opportunity, ecosystem services, earth history, and bio-heritage are known for people who are involved directly to forest and those that have affected indirectly. Billions of people are using forests for their shelter, livelihoods, water and food and fuel security. Forestry areas are habitat of 60 million indigenous people and home to 80% of the world's terrestrial biodiversity. Forests offer jobs for more than 13 million people across the world and countless people who are using forest products indirectly. Other ecosystem services of forests include decreasing climate change effects through absorbing greenhouse gasses, protecting water, soil and nutrients resources, mitigating natural hazards like floods and land mass movements, offering food and medicine, and storing a large amount of carbon and biomass inventory.

One of main steps of natural resources management is the comprehensive identification of their volume and terrestrial coverage. There are different definitions of forest in terms of their canopy cover and density (Schuck *et al.* , 2002). According to FAO (2015) definition, there are four billons ha of forests around the world where land has tree crown cover (or equivalent stocking level) of more than 10 percent and area of more than 0.5 ha. The trees should be able to reach a minimum height of 5 m at maturity in situ. Based on UNEP (2019) definition, forest replies to land with tree crown cover of more than 10 percent. According to such definition, there are 2.87 billion ha of forests around the world. Forest, Rangelands, and Watershed Management Organization of Iran has reported 11 million ha of forests in Iran by implying to the land with

tree crown cover (or equivalent stocking level) of more than 5 percent. On the other hand, forestry areas are facing to environmental problems, land use changes and socio-economic issues. Therefore, identifying and stating the problems, should be considered as one of the main steps of natural resources conservation.

Land degradation is one of on-site impacts of deforestation that is threatening the natural resources and food security. To state the problems, present research has focused on Hircanian forests that are distributed in the north of Iran. There is a long history for harvesting of timberlands in Iran, especially from Hircanian forests in the north of Iran (Bobek, 2005). The pre and post 1950 wood harvesting regardless of soil conservation have mainly controlled with great events such as wars, construction of main roads, settlements of population and authorized companies. Nowadays, there are 103 catchments in the north of Iran in which 50 authorized companies are harvesting timberlands. The annual rate of wood harvesting by such companies was 2.3 million m^3 between 1976 and 1991. Afterward, this rate was decreased to 300,000 m^3 per year. While, privates are responsible to harvest 3 million m^3y^{-1} without defined plan. Meanwhile, based on FAO (1990, 2015) reports, the area of Hircanian forests has been increased from 1,771,000 ha in 1990 to 1,939,494 ha in 2015. But, facing with 21, 16 and 10.5 t. $ha^{-1}yr^{-1}$ in the eastern, middle and western Alborz Mountain, north of Iran, respectively is one of the land and degradation features (Nikkami and Shadfar, 2020).

Existence of 6 million cattle and mining activities in 100,000 ha and more than 40 places of landfills and development of several access roads through the forests regardless of the conservation rules, have been made a complicated situation in the north of Iran. Accordingly, several rules and environmental acts have been released by national parliament (Act41, 1962; Act52, 1973; Act59, 1980; Act71, 1992; Act89, 2010; Act93, 2014). These regulations included comprehensive laws, strategies, policies and practices for different involved ministries, organizations, companies and end users. Lack of integrity between duties of stockholders was the big gap in such acts. In addition, weakness in structure of monitoring of the practices and undefined spatial planning of practices are other gaps for achieving the rules goals. Therefore, this research aimed to define a conceptual model to estimate impacts of deforestation, especially on-site soil erosion and to present policies and an action plan for land development regarding to conservation considerations.

Accordingly, the Technical Cooperation (TC) Project (IRA 5013) between Iran and the join division of FAO/IAEA, was agreed to investigate the impacts of deforestation and afforestation in the north of Iran and to introduce the applied model to conserve natural resources of forestry areas. The TC Project was supervised by the IAEA experts and details of the project activities were formed through Logical Framework Matrix (LFM), which approved by the IAEA technical officers.

Material and Methods

The study area: Hircanian forests are well known forests which are located along the south of the Caspian Sea, along the northern slopes of the Alborz Mountains in the north of Iran (Fig. 1). The Hircanian forests cover 1.85 million ha and include an important refugium of temperate broad-leaved trees, and date back to at least 25 million years BP. Up to 60 mammal species plus 340 birds, 67 fishes, 29 reptile and nine amphibian species recorded in various habitats of the region. The Hircanian forests stretch across three provinces of Guilan, Mazandaran and Golestan. Rapid increase in population accompanying with development of wood industries resulted in extensive deforestation and decline in coverage of Hircanian forests between 1942 and 2005. The study area has a semi-humid climate with maximum rainfall occurring in October and minimum in July. The mean annual precipitation in these areas are ranging between 2000 mm in west to 700 mm in east. There are microclimates along the Hircanian forests on the basis of distance to the Alborz Mountain Range and the Caspian Sea. In addition, continental polar and arctic, and modified tropical and polar maritime air masses have affecting the study area.

Research method: The research method was mainly defined based on evaluation of rules and regulations that mentioned above in terms of approaches, methods, road maps and outcomes. Formulation of methods (Fig. 2) was made to present conceptual model for assessing on-site and off-site deforestation impacts, to identify drivers, impacts, pressures, states and responses, to define watershed as geographical scale for implementation of practices, to suggest three approaches of the conservation, development and integrity, and

to achieve an action plan under three levels of conservation for activities. Synthesizing of conceptual model was carried out regarding the conflicts and coverage in land uses, desirability and proportionate of land uses, training and awareness of stockholders, and monitoring plan.

Reviewing environmental laws: There is a long history in Iran in terms of law and regulation release and implementation for interaction with forests and wood harvesting since the last three centuries. Because of variation in geographic and climatic distribution of forests in Iran, laws have brought advantages and disadvantages for people who have involved with forest and government agencies. Such condition has resulted in continued reduction in forest quality and quantity since the last 125 years that laws imposed by governments. International events have been forced the Iranian governments and local governors to change regulations and to increase rate of wood harvesting. For example, during the world wars I and II, forests have been harvested severely to support armies who have occupied Iran. In addition, changing in life style of Iranian people in big cities because of importing concepts and style of living from developed countries has increased wood demands by new developed relevant industries. Such situation, emerged continuous challenges between environmentalist, companies, and government agencies. Accordingly, several laws and regulations (Act41, 1962; Act52, 1973; Act59, 1980; Act71, 1992; Act89, 2010; Act93, 2014; Act96, 2017) have been released by government and the national parliament of Iran since the last 50 years that their brief concepts and implications is presented in Table 1.

The important and missing points of environmental laws: Reviewing of the main laws and regulations about conservation and utilization of forests and other natural resources and penalties for smugglers during the last five decades, has highlighted positive and negative points and aspects in terms of application and effectiveness. Following items represents the main important positive aspects of established laws and regulations:

- Cadastral surveying
- Conservation of bio-heritage and bio-resources
- Improving efficiency in forest harvesting
- Training and awareness of stockholders and end-users, 10 years' program
- Development of forestry data bank and information technology
- Involvement socio-economical consideration
- Providing fossil fuel for indigenous people of forests
- Ownership of privates especially for rangelands
- Translocation of cattle ranching from forests to specific areas out of forest
- Translocation of settlements from forests to border side of forest
- Programming for government cost share
- Emphasizing on watershed management and restoration of natural resources
- Determining of indicators for monitoring

Reviewing of the laws and regulations indicated some missing and negative points, which have caused complications in administration and management of forest and protection of trees from cutting and wood smuggling that presented as follow:

- Low integration in vision, mission, duties and activities of government agencies
- Separate approaches of conservation, development and integrity in programs of governors, authorized agencies and stockholders
- Implementation of thematic plans without consideration of performing scale
- Lack of considering to the level of conservation
- Conflicts of interests in land use (private-private, private-programmed, programmed-programmed)
- Development of lands regardless of ecological capability
- Development of lands regardless of loss of soil and nutrient resources
- Development of lands regardless of off-site impacts such as severe sedimentation and pollution in rivers, wetlands, and lakes
- Significant increase of flood events to 400 percent since the last five decades

- Significant increase of fires, landfilled, and mining in forestry areas
- Threatening several types and species of trees to extinction because of pest outbreak
- Lack of guidelines and stepwise operational plan
- Lack of operational plan to protect the access and transporting roads in forestry areas
- Applying try and error approaches in implementation of silvicultural practices

Problem statement and DPSIR model: Stating of the problems is the next step for devolving model following reviewing and evaluating laws and regulations and experiences that we received and knowledge that we learned since the last five decades. One of unique aspect of the suggested model is application of Fallout Radio Nuclide (FRNs) to quantify magnitude of land degradation in converted forest lands. Nuclear techniques introduced fallout radioisotopes of^{137}Cs, ^{210}Pb, and^{7}Be (IAEA, 1998) and conversion models (Walling, 2007) to estimate soil erosion/sedimentation as on-site impacts of deforestation (Gharibreza *et al.* , 2013b; Gharibreza and Ashraf, 2014; Gharibreza *et al.,* 2019). Further, ^{137}Cs,^{210}Pb, and ^{226}Ra radioisotopes and Constant Rate of Supply (CRS) Model and Constant Initial Concentration (CIS) Model are well-known tools (Robbins, 1978; Appleby, 1991; IAEA, 2005) to highlight off-site impacts of deforestation in terms of sedimentation in lakes and sink areas (Gharibreza et al., 2013a; Gharibreza et al., 2013c).

Stating of the on-site and off-site problems-induced by deforestation will be conducted using DPSIR framework. This framework has advantages in making cause and effects relations especially for clear cutting of forest as one of well-known man-made land use changes around the world. This model is widely used to identify driving forces of land use changes and consuming of natural resources, pressures that forcing on environment and human behaviors, states that dominated on environment and human resources, on-site and off-site impacts, and responses based on specific driving forces, pressures, states and impacts (EEA, 1999; Gisladottir and Stocking, 2005; Nuttle and Feltcher, 2013; Bradley*et al.,* 2015; Skondras and Karavitis, 2015). This model clearly highlighted importance of human resources and their roles in environmental changes and consequently effects of changes on human behaviors and health. Therefore, responses are indicators of human decisions regarding to socio-economic interests and management of resources consuming and restoration of natural resources in varied scale of space and time. Scaling of activities in forestry areas is one of missing points in administration and management of natural resources. We firmly believe that responses and management practices should be taken and implemented in the watershed scale. Accordingly, in suggested model the concept of Integrated Watershed Management (IWM) has been dominated for presenting responses in DPSIR model. Adopted the driving forces, pressures, states, impacts and responses based on deforestation in the North of Iran is presented in Fig. 3.

Spatial planning of the watershed based on level of conservation: The model steps will be continued by spatial planning watershed on the basis of conservation levels. This step is necessary prior implementation of management practices or DPSIR model responses. Spatial planning will be carried out based on slope percent and biodiversity of flora and fauna species.

One of the most important approaches in IWM is conservation of natural resources. There are conflicts of interest between end users to use natural resources of forestry areas of Iran especially in Hircanian forests. Lack of understanding in concept of conservation among decision makers have resulted in complication in implementation of environmental acts. Therefore, this model clarifies levels of conservation to provide suitable background for given responses to driving forces, pressures, states and impacts of deforestation in IWM media. Accordingly, levels of conservation represent scale and measure of development approach in a forestry watershed (Fig. 4). This concept of conservation levels and management approaches has been used in Integrated Coastal Zone Management (ICZM) of Iran (PMO, 2008), where demands for natural resources of the Caspian Sea coastal area or Hircanian forest is increasingly very high.

Conservation level points to sustainable land use while still extracting natural resources. Spatial distribution of the converted forest lands, fired forest, rangelands, dry-farming lands, silvicutural lands, horticultural lands, other farms, attack of invasive species, biodiversity depletion, blighted areas, degraded lands, over harvested lands, polluted areas, sound, light and other pollutions, landslides, flooded areas (25 to 100 years return periods), debris flows, eutrophication, and other land uses will be classified in the conservation level.

This level implies to management practices to remade and restore destroyed resources and to support exist natural resources. These kinds of practices are remarkably depended on significant collaboration of people with people and government with people. Berkes*et al.,* 1995 suggested prescriptions for community-based conservation by which open access to forestry areas eliminated, balance resources-use right of the local people with responsibilities, and legally protect land tenure of the local communities (Berkes *et al.,* 1995). Renewable of natural resources is one of the main practices of such level of conservation. This means limiting their consumption to a rate slower than their replacement rate. Further, reforestation of clear-cut lands under programmed policy and arrangement of land use in desirability with adjacent activities are other management practices of conservation level.

Conservation with higher consideration is classified in protection level in which natural resources will be protected mainly from the natural and artificial threats. Spatial distribution of biological sensitivity classes, physical sensitivity, important bird's habitat, forest reserves, no hunting, no shooting, national very important habitats, scientific, educational and monitoring, vulnerable, wildlife concentration, and areas with high wildlife diversity and slopes between 10 to 20% will be classified in the protection level.

Land use changes and wood harvesting are main two features of deforestation, which causing on-site and off-site impacts. The DEPSIR model will response to pressures, states, and impacts that imposed on environment and human by considering to protection practices. Such level of conservation implies mainly on restoration and remediation practices with limited harvesting of natural resources such as dropped trees. Forestry areas that located in this level of conservation will be limited for local people also and authorized companies have right to contribute for stewardship and protecting practices. Protection level might be having patchy and zoning spatial pattern. Scatter pattern implies on management practices around the watershed to control and mitigate recognized natural hazards, while in most cases protection area represents buffer zone for preservation level area. Some minor land use in such level of conservation should be implemented with considering to hydrological and ecological setback and buffer zones regarding to important natural resources. In addition, environmental friendly activities and land uses should have maximum desirability and minimum conflict with adjacent activities.

The highest measure of conservation regarding to natural resources in a watershed scale will be carried out in preservation level. Spatial distribution of protected areas, biosphere reserves, Ramsar sites, the highest biological sensitivity, the highest physical sensitivity, gene pools, bio-heritage, geo-heritage, national important habitats, rare habitats, and slopes higher that 20% will be classified in preservation level.

In such level, non-renewable natural resources, like unique flora and fauna species can be conserved by maintaining a sufficient amount to be utilized by future generations. Preservation typically refers to the setting aside of areas of land that are either human-free, free of obvious marks of human influence like roads or fire pits, or whose sole human inhabitants are native people. Special policies and activities will support preservation of the geo and bio heritages because of their ecological importance and genetic reserves. This level of conservation finally was legally (Act96, 2017) released to preserve the Hyrcanian forest through breathing forest for ten years. Although, this law was the most compatible with preservation level, but it mostly is comparable with conservation and protection levels. According to (Act71, 1992) law, distribution of conservative forest should be increased to 90% that emphasized on increase of conservation consideration from lower levels to the highest degree. Although, these laws were presented sustainable objectives, but they have not guided users to reach goals.

Spatial planning of the watershed based on ecological capability: The model methodology will be continued by spatial planning of the conservation and protection level areas based on ecological capability. Management plan should present land use planning for these two areas in order to define sustainable using of natural resources. The first phase is to find out equilibrium and nonequilibrium in using of natural resources by present land users. The next step is to identify desirable land use for future land development projects. Accordingly, ecological capability of allowed areas for specific land uses will be measured based on the soil and water resources and topographical characteristics (Fig. 5).

Overlaying thematic maps which developed based on ecological capability of watershed on distribution of the present land uses and maps of programmed land uses will highlight compability and conflicts of them with useable natural resources. Compability of current land uses demonstrates desirability of the in terms of spatial planning and using of natural resources and sustainable developed lands. Similarly, compability of programmed land uses with ecological capability represents desirability for development specifically in conservation level areas. In contrast, bias from compability indicates undesirability in land use and un-sustainable developed lands. The model solution is to use multi criteria decision making methods to present desirable locations for un-sustainable developed lands, find out the best and more desirable programmed land use plan in terms of conservation considerations and compability with ecological capability.

Furthermore, long-term land use plans by authorized organizations which are involving in forestry areas should be accomplished in defined time scales. Some programs have conflict of interests in terms of spatial distribution and using of natural resources because of overloading of population and demands for services and productions. Such condition is severely in challenges with forest breathing law that has forced users to terminate all of contracts. While, this model gives opportunity to users to select desirable land use based on measured ecological capability in conservation level area.

Conflicts of interest in land use is another situation in watershed that has considered properly by this model. Overlying maps of present land uses and spatial plan of programmed land uses will highlight three spatial conflicts of interests (Fig. 5). Conflicts in plans of current land uses and between current land uses and programmed land use plans, and finally between programmed and programmed land use plans are inappropriate driving forces for deforestation that decision makers are facing to their pressures, states and impacts. For such situations, therefore, this model takes account to level of conservations as applied solution to omit inappropriate land uses in protection and preservation level areas. Improving rules and terms of applying of land use is the next step to achieve priority in land demands who are more compatible with environmental acts and conservation considerations.

Supportive parts of model: One of main approaches of the management model is achieving to the highest integration between plan of organizations, and between plan of organizations and delegates of people societies. Integration is vital approach of the IWM by which the plan of conservation practices and the most compatible plan of land development with ecological capability will be obtained. Accordingly, the first supportive part of the management model is program of stockholder's cooperation. Stockholders includes all organizations and people those by environmental acts directly and indirectly have committed to implement duties in terms of conservation and land development. Evaluation of management plans since the last decades has indicated the gap in which representative stockholders of forestry watersheds have implemented separate duties, although laws and acts have firmly recommended the framework activities.

Previous experiences (JICA, 2003; ICZM, 2008; Tohidifar *et al.,*2016; UNDP, 2018) in terms of integration in duties and activities of environmental organizations demonstrated that professional committees in different scale of national, provincial, and local should be created with certain responsibilities regarding to conservation and development plans. For instance, Caspian Hyrcanian Forest Project that implemented with cooperation of Forest, Rangelands, and Watershed Management Organization (FRWO) of Iran, UNDP, and GEF (2013-2018) created administration groups which had duty integration and inter-sectoral coordination. Regional and local inter-sectoral coordination mechanisms was established under a memorandum of understanding between FRWO and governors of three provinces in Caspian Hyrcanian region. In addition, through participatory management of forest basins the integrated management plans were developed for four pilot sites of the project to be implemented from mid-2016. Seven coastal provinces of Iran, included three provinces of Hircanian forests under Integrated Coastal Zone Management (ICZM, 2008) have special committee involving wide range of executive and military organizations that periodical are considering coastal problems and issues which have raising in conservation and development of coastal areas. Although, ICZM also emphasized on integration in duties and activities, but its management boundaries are not cover watershed scale.

Therefore, this model has emphasized on IWM plans to cover missing points of previous models in terms of

conservation levels and land development desirability while it considers to livelihoods of local communities through empowering and training courses.

The model supplementary parts might be included the geodatabase and decision support system. These are applied and powerful tools for implementation of management strategies and practices in different parts of watershed in terms of conservation, development, and integration between organizations who are involved in watershed management (Makhdoum, 2002). Geodatabase will be formed using ISO, 19115 standards through loading of GIS-ready layers of natural resources, current and programed land uses, soil, topography, slope, geology, physiography, old land use, agriculture, aquaculture, industries, urban and village, road, transportation, waterbody, river, stream pattern, mining, landfill, and other maps with similar coordinate system.

Further, produced thematic maps such as specific maps of land uses based on ecological capability will be loaded in the geodatabase. In addition to such maps, spatial zoning of potential hazards such as seismicity, flood, instability and mass movements, hydrological and agricultural drought will be added. Spatial distribution of Ramsar sites and other thematic protected areas will be included in the geodatabase.

Finally, all basic and produced GIS-ready layers will be arranged in decision tree algorithm. A model-driven decision support system includes spatial planning input and output data that represents compatible, desirable and appropriate land uses regarding to ecological capability. This system presents information about natural hazards in given spatial plans as well as basic geo-based data for decision makers.

Results

Responses to driving forces, pressures, states, and impacts of deforestation: Problem statement showed variety of driving forces, pressures, states, and impacts of deforestation in the north of Iran. According to DEPSIR framework, specific responses have obtained which can be divided on the basis of conservation, development, and integration approaches in the watershed management scale. Indeed, responses are management practices taken by decision makers to prevent, compensate, ameliorate or adapt to changes in the state of the environment (Bradley *et al.,* 2015) and to modify human behaviors that contribute to land use changes, to compensate for social or economic impacts of some critic laws and regulation regarding to implementation of conservation consideration.

Driving force-based responses: These responses points to preventive, control and adaptation policies and economic decisions that directly affected main driving forces.

- Taking preventive policies by organizations based on environmental acts to reduce wood consumption by locals and industries. Providing other available fuels for daily consumption of local people instead of wood. Mobilization of families to new equipment for using other sources of energy especially renewable ones like solar systems is firmly recommended
- Taking multi-purposes policies instead of one-side policy like the forest breathing law by government on the basis of conservation levels areas, in which locals and authorized companies permit to wood trading with conservation considerations
- Creating investment fields to change interest of ownership of land in the North of Iran
- Taking policy of importing compatible wood to developed wood industries instead of wood harvesting
- Taking adopting policies by government to change livelihood style of local and related people from forest-based to the forest-related styles
- Taking control policies by government to evacuate nonnative peoples from forest areas to margin of forest especially luxury cities
- Taking control policies by government to evacuate cattle ranching peoples from forest areas through creating suitable infrastructures by empowerment of cattle owners
- Taking preventive and incentive policies by government and relevant organizations to manage tourist activities and related demands of land based on conservation considerations, changing undesirable tourist land use should be fulfilling in the first priority

- Taking preventive policies by government to minimize new road construction and repair old roads and transportation facilities to reduce side effects on soil erosion and mass movements where created by roads on steep slopes
- Taking preventive policies by government to ban charcoal trading forest-based and changing to forest-lateral-based trading

Pressure-based responses: Pressures are defined as human activities, derived from the functioning of Social and economic driving forces that induce changes in the environment. Environmental pressures may include discharges of chemical, physical, or biological agents, land use changes and direct contact uses. The intensity of environmental pressures depends on the technology and extent of source activities and can vary across geographic regions and spatial scales. Accordingly, stating of the problems induced by deforestation in the north of Iran highlighted pressures on environment and human behavior. therefore, management practices or responses presented which indicated their conservation, development, and integration approaches in IWM scale. The pressure based-responses have concept of managing of land resources uses, waste discharged, human behavior and habitat, and training and awareness.

- Implementing preventive and incentive management practices to change converted forest lands to desirable uses regarding to ecological capability
- Implementing preventive and incentive management practices to change converted forest lands to desirable programmed land uses on the basis of ecological capability
- Taking priority for land use of converted forest, where not conflict between adjacent present land uses and between present and programmed, and between programmed and programmed land uses
- Performing preventive management practices to reduce consumption pressures on forestry natural resources by organizations and locals in order to reach equilibrium in the permitted and standard levels
- Implementing preventive management practices to optimize discharge of waste waters discharges in watersheds of Hircanian forest to reach equilibrium in the permitted and standard levels in terms of quantity and quality. This response is vital for watersheds where wetlands, open waters, lakes and coastal bays are existence in different topography altitudes
- Performing preventive management practices to optimize cattle grazing pressures on rangelands of forest watersheds in an appropriate space and time scale
- Implementing preventive management practices to minimize pressures on environment because of land-fill development through empowerment of local governors to improve recycle facilities and land filling techniques
- Implementing watershed management practices to decrease rate of runoff from converted forest lands to reduce flood pressure on environment, urban and village infrastructures, and livelihood sources
- Implementing watershed management practices to decrease pressures on converted forest lands in terms of soil loss especially in dry-farming agriculture in the Mazandaran and Golestan Provinces
- Implementing adopting management practices to change forest-based livelihoods of locals and related people to the non-forest depended livelihoods
- Implementing training management practices to change and optimize forest-based lifestyle of locals and related people to non-forested depended lifestyle
- Implementing training and awareness management practices to change and optimize social behaviors in order to decrease dependency to forest
- Performing preventive management practices to avoid settlement of non-native and immigrant people especially in in converted forest lands and in the protection and preservation areas
- Performing preventive management practices to decrease pressures on natural resources through avoiding wood smuggling from Hyrcanian forests

State-based responses: State which dominated in the north of Iran because of deforestation have both environmental and human-related aspects. Accordingly, responses imply on supervision, revitalization, rehabilitation, monitoring, and restoration of forest watershed natural resources. Further, practices include empowerment of local governors and people to encounter deforestation-induced state in the North of Iran.

- Monitoring on performance of organizations those are involved in land development projects
- Empowerment of local governors to reclaim converted forest lands from illegal land users for reforestation (afforestation practices)
- Revitalization of degraded lands due to deforestation using conservation practices
- Supervision on implementation of programmed land use plans on the basis of conservation considerations
- Installing rainfall water harvesting to compensate shortage in water resources especially in low land part of forest watersheds
- Supervision on development of new agricultural crops, horticultures and aquaculture basins in terms of compability with ecological capability and probable conflict with adjacent land users
- Revitalization of canopy cover in converted forest lands through afforestation of degraded and agricultural lands especially in the east of Mazandaran and whole area of Golestan Provinces
- Restoration biodiversity of converted forest lands especially in terms of quality and quantity of flora and fauna species in the north of Iran
- Supervision on industrial plantations by authorized companies in terms of their compability with ecological capability and soil and nutrient conservation
- Remediation and rehabilitation of soil fertility because of deforestation especially in the Mazandaran and Golestan provinces
- Reduction of water turbidity from converted forest lands through construction of retention pounds before natural lakes, wetlands and coastal zone
- Rehabilitation of wild animal habitat in protection and preservation levels areas to compensate their migration from converted forest lands
- Supervision on new incomes of owners of converted forest lands through collecting of environmental taxes for conservation considerations
- Prohibition from illegal ownership of converted forest lands and smuggling of wood from occupied lands

Impact-based responses: Impacts of deforestation in the north of Iran indicates on-site and off-site changes in the quality and functioning of the ecosystem. Such changes have effects on the forest services, production, ecosystem, and human well-being. In point of view of IWM, deforestation is destructive land use in terms of soil, water, vegetation covers on the converted forest lands that decrease services of the watershed and increase instability and hazards which created by nature and strengthened by human activities. Therefore, responses to impacts include management practices to compensate un-equilibrium in resources and relevant process in aspects of the environment and human well-being. Responses implies on the management practices to mitigate and control, evaluation and monitoring, and compensate of deforestation impacts in order to empower ecosystem of converted forest lands to revitalize its cervices.

- Appropriation of lands for forestry activities in converted forest lands as the first priority to compensate lost natural resources in the north of Iran
- Plantation of converted forest lands by compatible trees with ecological capability through silviculture techniques (government) and horticulture (locals) to compensate degradation happened during deforestation. There are successful silviculture activities in plantation of harvested lands since the last four decades in the North of Iran. Meanwhile, horticulture practices in cultivation of olive trees were not successful in terms of soil and nutrient conservation, but it was effective in livelihood improvement
- Taking Integration approach of roadmaps strategies, approaches, and management practices of involved organizations and private sectors through creation of professional committees in the national, provincial, and local scales in order to convergence duties and budget and to implement desirable land use plans with regarding to conservation considerations
- Implementation of soil and sediment remediation practices using biological and chemical techniques to mitigate pollutions as off-site impacts of deforestation. Such responses proliferate environmental services and guarantee human health
- Implementation of management practices to control water quality and water quantity of the converted forest lands. Such practice can compensate ecological capability of watershed for future environmentally

friendly land uses

- Evaluation and monitoring of financial transactions by government in order to find out wood smuggler economical routes to mitigate and control of illegal activities
- Spatial monitoring of wood smuggling to mitigate willing for illegal income through mobilization of watchdogs and forest rangers
- Creating of retention pounds and other sediment traps to reduce sediment transport from converted forest lands into natural and artificial lakes, wetlands and coastal areas especially in 12 watersheds of Anzali Lake in Guilan Province and three watersheds of Gorgan Bay in Golestan Province
- Implementation of dredging and bioremediation practices in natural and artificial lakes and coastal bays to mitigate and control of eutrophication and to improve ecological services for aquatic life and birds
- Prohibition from forest firing during deforestation and annual firing of farms in converted forest lands (dry-farming in high-lands and rice farms in low-lands), to mitigate rate of eutrophication of water bodies
- Taking geotechnical practices to control mass movements such as land slide and debris flow from converted forest lands specially areas where transportation projects have implemented
- Taking management of food security in watersheds where converted forest lands have mainly changed livelihood style. Restoration of food resources to reach balance for locals and related people will decrease social impacts of deforestation
- Restoration of marine or aquatic life of lakes and coastal bays, where have experienced severe shoaling through dredging and fishery practices to increase food security
- Empowerment of local people who experienced damages from deforestation through insurance and supportive practices

Thematic maps of specific land use in the Hircanian forests based on ecological capability: In this section of results, sample of spatial zoning of desirable land use plan on the basis of ecological capability in the north of Iran is presented to indicate output of the suggested conceptual model. Few studies for achievement to desirable land use planning in Hircanian forests (Onagh *et al.,* 2006; Amiri*et al.* , 2009; Danekar *et al.,* 2019). Previews studies have been conducted in some representative catchments in Guilan, Mazandaran and Golestan provinces. Presented sample was selected from the Caspian Hircanian Forest Project (Danekar *et al.,* 2019), which has implemented in agreement between FRWMO of Iran and UNDP-GEF (2013-2018). One of the main outcomes of the project was spatial planning for some specific land uses such as agriculture, conservation, and tourism based on ecological capability of four representative watersheds which have been produced based on Makhdoum method (Makhdoum *et al.,* 2010; Makhdoum, 2014). This model evaluates ecological capability using GIS-ready layers of slope, erosivity of soil, erosion rock resistivity, soil infiltration, geohydrology, biodiversity of fauna, value of flora species, value of fauna species, habitat tendency, biological habitat type, cultural values, and protected areas. Linear planning equations formulate for ecological conservation scenarios. Such scenarios obtained by variety of situations in which mentioned factors assumed stable variable and others to be changing variables. For instance, spatial plan of the protected areas depends on all other variables, while erosivity of soil depends on erosion rock resistivity, soil infiltration, geohydrology, biodiversity of fauna, and value of fauna species factors.

Fig. 6 shows spatial planning of management practices in the Hircanian forests in which conservation was divided to three types of ecological, physical and periodical. Actually, these management practices are compatible on conservation and protection levels areas where land use changes have been happened in variety of scales. Further, ecological and physical conservation represent the biotic and abiotic practices, respectively. Practices, also implies on state-impact-based responses encounter to dominated situations and effects which induced by deforestation those are tangible in forest watersheds. Such practices are manly having mitigation, control, monitoring, restoration, remediation, revitalization, preventive, and incentive concepts.

According to Danekar *et al.* (2019), conservation considerations should be implemented on about 58% of the Hircanian forest. These areas are under threatening stability and equilibrium of watersheds and have

experienced artificial and natural hazards. In addition, 36% of such areas have level of preservation that representative of the biodiversity of the Hircanian forests. On the other hand, 16% of the Hircanian forests are vulnerable and instable which needs high level of conservation specially implementation of mechanical, biomechanical and biological management practices. These areas are undesirable for present and programmed land use plans, and therefore, land development projects are firmly prohibited. Furthermore, 5% of the Hircanian forests needs revitalization, rehabilitation, remediation and significant conservation practices in short and long-term time periods. In addition, Results indicated that 86% of spatial distribution of rangelands in the Hircanian forests are in un-equilibrium or under pressure of land users such as overgrazing and dry-farming activities. Urgent driving-forced responses from relevant organizations are needed to prohibit and manage present land uses to reach compatibility with ecological capability. Results also highlighted undesirability of programmed silviculture plans regarding to ecological capability in terms of spatial distribution and methods of cultivation. Gharibreza *et al.* (2019) stated that silviculture methods which implemented for cultivation of industrial wood in converted forest lands in Golestan Province had have moderate to low effectiveness in terms of soil conservation. Un-even aged cultivation of different types of trees as common method that have been used by authorized companies along the Hircanian Forest need reconsideration particularly for future projects.

Action plan of the conceptual model: The model action plan includes thematic responses or management practices on the basis of driving forces, pressures, state, and impacts of deforestation in the north of Iran. Conservation, development, and integration are three approaches that guide the action plan to reach given goals of the model. As above explained, operational activates of conservation should be performed in three levels of conservation, protection and preservation based on spatial zoning of forest watershed. This model firmly recommended integration in activities and missions of all stockholders through concept of IWM and separated projects of conservation and development not allowed. As already mentioned, professional committees in different scale of national, provincial, and local should implement duty of integration approach. In addition, adopted land development project with ecological capability should be supervision by committee allowed only in conservation level area. The action plan should focus retrieving and restoration activities on the protection and preservation level areas. Such activities include mechanical and biological management practices that should be implemented in converted forest lands in the first priority. The professional committees have difficult duties to provide adopted alternative livelihoods for locals who are living in the converted forest lands. In addition, changing livelihoods should guarantee their income and mitigate wood smuggling from the Hircanian through incentive and insurance policies.

The model has specifically implied to responsible stockholders who should implement the action plan in classified responses based on driving forces, pressures, state, and impacts of deforestation in certain time period (Fig. 7). For instance, some professional activities should be performed by related stockholders under responses to deforestation-induced pressures on environment in the converted forest lands or on human behaviors who are living there. Accordingly, any bias from the model objectives will highlights negligence in duties that responsible stockholder should had to implemented. The action plan offers one-year opportunity to the responsible organizations for problem statement and to find out responses under the supervision of the ministries of agriculture and interior of Iran. Thematic technical reports and spatial plan of issues and relevant responses by responsible organizations are main outcomes that the professional committees should be approved for implementation in the second step of the action plan.

The implementation step offers five-year time period to responsible organizations under action plan with an integration approach to implement their duties. Fig. 7 represents the brief management practices that explained above based on driving-force, pressures, state, and impacts of deforestation in the north of Iran. Management practices should be performed based on the measurable indices and certain milestone (Fig. 8). Preventive and precaution policies should minimize new deforestation and regulate lend development projects in future based on spatial land use planning. Pressures on environment and human should be relief according to measurable indices, meanwhile deforestation-induced unsuitable state and impacts especially on-site effects should be mitigated and controlled properly.

The third step of the action plan indicated the evaluation and monitoring of management practices (Fig. 7). Three approaches of conservation, development and integration should be considered as main quality indices of the management practices. The model milestone for the third step is two years after implementation of practices when results could be measurable. Evaluation and monitoring have two sides in which some taken management practices might be changed, if their methodology and results incompatible with objectives of action plan.

Discussion

This model has considered all previous rules and guidelines of development and conservation of Iran and presents comprehensive program to manage current and programmed land use to solve conflict and undesirability. Suggested steps increases the ability of managers to implement conservation practices in forestry areas, where there is un-sustainability in land uses. In addition, the model has introduced the development approach in which land use changes will be implemented under conservation considerations. For instance, development projects should be conducted biological and mechanical practices to mitigate soil erosion and sediment transport to lakes and lagoons. Integrity approaches make a convergence in policies and activities of organizations who are involving in harvesting the forest and conserving the natural resources. Comparison of present conceptual model with previous models (Kaimowitz and Angelsen, 1998; Aukland *et al.*,2003; Tejaswi, 2007; Feng *et al.* , 2014; Indarto and Mutaqin, 2016) showed that this model like previous ones has considered comprehensively purposes, methods and impacts of deforestation. Further, this model has several privileges in terms of methods, approaches, level of conservations and supportive sub-models for spatial planning, programming of action plan, management practices, and evaluation and monitoring. For instance, conservation zoning of watershed into three levels of conservation, protection and preservation is novelty of the model which concentrate practices and budget toward degraded lands and areas where needs urgent conservation.

Another specific aspect of this model is formulating of the action plan on the basis of driving forces of deforestation and resulted pressures, state, and impacts particularly in converted forest lands. In addition, off-site pressures, state, and impacts of deforestation on environment and human resources has been considered properly. Reviewing of similar models indicated that they have not considered responsibility of stockholders in implementation of practices, while this model provides guideline for responsibility of involved organizations based on specific responses. In addition to responsibility of organizations, the action plan of this model highlighted thematic and spatial planning outcomes of operational steps to find out their effectiveness. Existence of evaluation and monitoring step of the action plan is another strength of this model to measure effectiveness of management practices and to change manner and nature of unsuccessful responses. Supervisor for monitoring would be selected from the most important organizations of the Ministry of Agriculture, therefore, they would be responsible for bias and variation in planned states.

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Figure Legend

Fig. 1- Hircanian forests distribution as a green belt in the north of Iran

Fig. 2 - The logical framework matrix used to achieve the conceptual model

Fig. 3- Drivers, pressures, states, impacts and general responses based on deforestation in the north of Iran

Fig. 4- Conservation levels and allowed land use changes in forest watersheds

Fig. 5- Measuring desirability of present and future land use by ecological capability

Fig. 6- Spatial planning for conservation of Hircanian forests (Danekar *et al.,* 2019)

Fig. 7 - The action plan of the conceptual model and its steps and milestones

Fig. 8- The synthesized conceptual model for conservation of natural resources of forest watersheds

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