CHAPTER 6

CONCLUSIONS & FUTURE RECOMMENDATIONS

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6.1 CONCLUSIONS

Excavation of coal by underground mining method leads to subsidence that involves the movement in subsurface strata. Subsidence may affect the surface vegetation and forest ecosystem. The present work attempts to assess the impact of mining induced subsidence on the health of plants. Three different approaches have been used (1) study based on laboratory model, (2) field study, and (3) remote sensing study. Surface subsidence results in change in surface profile. The ground has variable movements resulting in compressive and tensile strain zones. The nature of strains (i.e., compressive and tensile), along with their magnitude, has impact on the plants. The following conclusions have been drawn from the present study.

1. **The plants' health gets affected by surface subsidence.** The health of the plants has been assessed with the help of various plant growth parameters (biomass, vegetation water content, chlorophyll content, soil moisture, leaf area index and plant height). It has been observed that most of the parameters deteriorate in tensile strain zone and improve in compressive strain zone. Similar results have also been obtained in field study where soil samples and plant samples have been analyzed. The nutrient concentrations decrease in tensile strain zone and improve in compressive strain zone. The overall impact assessed by remote sensing study over a subsided panel gives indications that the plants' health gets affected by subsidence.

2. **The horizontal tensile strain damages the plants adversely.** In laboratory investigation, the plant growth parameters in tensile strain zone have been compared with control condition (unsubsided). It has been observed from the laboratory investigation that most of the plant growth parameters (biomass, vegetation water content, chlorophyll content and soil moisture) deteriorated with increasing horizontal tensile strain. Similar study has also been carried out in field investigation where nutrients in soil and plants have been studied. It has been compared with the plants of unsubsided zone. Field studies also suggest that the plants' health get damaged as compared to the unsubsided zone.

3. **The plants health improves in compressive strain zone.** The plant growth parameters have been studied in compressive strain zone in the laboratory and in the field. The growth parameters improve in compressive strain zone compared to control condition in laboratory investigation. Similar results have also been obtained in the field investigation.

4. The value of horizontal tensile strain has been increased progressively in laboratory investigation. The plant growth parameters decline with the increase in horizontal tensile strain. It has been observed that after a certain horizontal tensile strain, the plants' health decreases rapidly. **The critical value of horizontal tensile strain beyond which the plants get damage rapidly has been observed as 10 mm/m in the present study.**

5. The value of horizontal compressive strain has been increased progressively in laboratory investigation. It has been observed that the plants' health improves with horizontal compressive strain. However, it has also been observed that with further

horizontal compressive strain, plants' health deteriorates. Therefore, it can be concluded that **slight compression due to subsidence improves the plants' health, but excessive compression may lead to the deterioration of the plants.**

6. The soil samples have been collected from subsided (tensile and compressive strain zones) and unsubsided zone for textural analysis in the field investigation.
   a. The percentage of coarse textured soil, i.e., sand, increases in tensile strain zone by 0.71% while it decreases in compressive strain zone by 4.6%.
   b. The percentage of fine textured soil (silt and clay) decrease in tensile strain zone by 10.34% and 11.60%, respectively and increase in compressive strain zone by 12.01% and 13.95%, respectively.

   The tensile strain zone shows more of coarser grain (sand), whereas compressive strain zone has higher fine textured soil (silt+clay). Fine grained soil is a good accumulator of nutrients and holds water for a longer period of time. Plants' health will consequently improve in compressive strain zone, whereas it will deteriorate in tensile strain zone.

7. Nutrients in soil have also been analyzed from subsided (tensile and compressive strain zones) and unsubsided zones in field investigation.
   a. The available nitrogen decreased in tensile strain zone by 3.5%, while it increased in compressive strain zone by 14.98%.
   b. The available phosphorus decreased in tensile strain zone by 11.26%, while it increased in compressive strain zone by 21.4%.
   c. The available potassium decreased in tensile strain zone by 3.58%, while it increased in compressive strain zone by 24.15%.

All important nutrients in soil have significantly improved in compressive strain zone, whereas it has deteriorated in tensile strain zone. It could be concluded from above that the plant health improves in compressive strain zone and deteriorate in tensile strain zone.

8. Leaves of plants have been collected from the field in subsided (compressive and tensile strain zones) and unsubsided area. The important available macro and micronutrients have been determined in the laboratory. **All macro and micronutrients have deteriorated in the tensile strain zone, whereas improved in compressive strain zone compared to unsubsided area.** The following changes in nutrient contents have been observed in tensile and compressive strain zones.

a) The nitrogen concentration decreased by 1.1% in *Shorea robusta* while by 0.64% in *Lantana camara* in tensile strain zone. The Nitrogen concentration increased by 2.2% in *Shorea robusta* and 0.09% in *Lantana camara in* compressive strain zone.

b) The phosphorus concentration decreased by 7.77% in *Shorea robusta* while by 9.97% in *Lantana camara* in tensile strain zone. The Phosphorus concentration increased by 11.65% in *Shorea robusta* and 7.22% in *Lantana camara* in compressive strain zone.

c) The potassium concentration decreased by 6.1% in *Shorea robusta* while by 1.63% in *Lantana camara* in tensile strain zone. The Phosphorus concentration increased by 10.33% in *Shorea robusta* and 1.43% in *Lantana camara* in compressive strain zone.

d) The concentration of calcium decreased by 11.65% in *Shorea robusta* while by 1.64% in *Lantana camara* in tensile strain zone. The Calcium concentration

increased by 5.69% in *Shorea robusta* and 2.46% in *Lantana camara* in compressive strain zone.

e) The concentration of magnesium decreased by 0.74% in *Shorea robusta* while by 1.82% in *Lantana camara* in tensile strain zone. The Magnesium concentration increased by 1.11% in *Shorea robusta* and 1.33% in *Lantana camara* in compressive strain zone.

f) The sulphur content decreased by 8.43% in *Shorea robusta* while by 3.49% in *Lantana camara* in tensile strain zone. The Sulphur concentration increased by 10.84% in *Shorea robusta* and 2.21% in *Lantana camara* in compressive strain zone.

g) The concentration of manganese decreased by 1.64% in *Shorea robusta* while by 1.83% in *Lantana camara* in tensile strain zone. The Manganese concentration increased by 1.34% in *Shorea robusta* and 1.63% in *Lantana camara* in compressive strain zone.

h) The concentration of zinc decreased by 2.56% in *Shorea robusta* while by 0.51% in *Lantana camara* in tensile strain zone. The Zinc concentration increased by 2.56% in *Shorea robusta* and 6.06% in *Lantana camara* in compressive strain zone.

i) The concentration of iron decreased by 5.71% in *Shorea robusta* while by 3.33% in *Lantana camara* in tensile strain zone. The Iron concentration increased by 3.57% in *Shorea robusta* and 6.67% in *Lantana camara* in compressive strain zone.

j) The concentration of copper decreased by 3.95% in *Shorea robusta* while by 2.49% in *Lantana camara* in tensile strain zone. The Copper concentration increased by 5.26% in *Shorea robusta* and 3.73% in *Lantana camara* in compressive strain zone.

9. Remote sensing study has been carried out to find out the overall effect of subsidence on plants, i.e., combined effect of both tensile and compressive strains on the greenness of the plants. This study was based on NDVI (Normalized Difference Vegetation Index) calculation. The vegetation was classified into two categories, i.e., healthy vegetation and unhealthy vegetation, based on NDVI. **The area of healthy vegetation has decreased from 38700 m^2 to 22500 m^2 (-41.86%). The unhealthy vegetation has increased from 40500 m^2 to 56700 m^2 (+40%).**

6.2 FUTURE RECOMMENDATIONS

In this thesis, a sincere effort has been made to quantify the impact of coal mining subsidence on vegetation and forest cover. The following suggestions are recommended to quantify the impact of mining induced subsidence on vegetation for Indian geo-mining conditions:

- Data collection on subsidence, soil and native vegetation are required to be done for longer times before and after the completion of extraction in the selected panel.
- Similar study should be undertaken in other coalfields located in other phytogeographical regions of the country to generalize the effect of surface subsidence due to subsidence on vegetation for Indian geo-mining conditions.