1. INTRODUCTION

Water resources in many countries are currently under severe pressure due to human intervention and the changing of runoff patterns caused by climate and land use/cover changes. A population growth and human-induced development have accelerated the speed of land use/cover changes that in turn affect hydrological processes, and thus water availability and demands. In addition, climate change may affect many aspects of natural ecosystems. Hence, comprehending of climate change impacts on hydrological conditions is essential to enable more efficient water resources development.

In this study, the impacts of climate, population and land use/cover changes on water availability and demands and water stress in the Srepok River basin were assessed, individually or in combination. This is achieved by developing future scenarios of climate, population and land use/cover changes; and by examining future water stress situation using the calibrated hydrological model under different developed scenarios across 13 sub-basins.

2. METHODOLOGY

**Hydrological Model:** Stream flow was simulated using HEC-HMS model on daily basis and the results were calibrated to observed daily stream flow data in period of 1978-1992 at two stations (Cau 14 and Ban Don). The calibrated parameters were then used for model validation in period of 1993-2007. The calibration and validation results were evaluated of the goodness of fit by three criteria: NSE, PBIAS and RSR1 at daily and monthly time scales.

**Land Use/Cover Change:** A simple approach - a GIS-based logistic regression2 was used in this study to predict future land use/cover. The relationship between spatial distribution of each land use type and its driving factors was determined using logistic regression analysis; and the probability maps were produced, accordingly. Land use types were then predicted considering the produced probability maps, the actual land use maps, conversion elasticity, and future land use demands. Land use types were calibrated against land use map in 1993 and validated to land use map in 1997.

**Water Availability and Water Stress Index:** The stream flow at outlet of the three gauged sub-basins was used to disaggregate for water availability of the remaining ungauged sub-basins based simply on the areal proportion3. The water stress index (WSI)4 was used to examine water situation in the study basin. The index was applied for basin and sub-basin levels to evaluate water stress situation.

**Scenario Development:** Five scenarios were developed to examine the impacts of different changes on future water resources and demands, and thus water stress as listed in Table 1.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Climate</th>
<th>Population</th>
<th>Land use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate change</td>
<td>AGCM-A1B</td>
<td>2000</td>
<td>1997</td>
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<tr>
<td>Land use change</td>
<td>1978-2007</td>
<td>2000</td>
<td>2050</td>
</tr>
<tr>
<td>Combination</td>
<td>AGCM-A1B</td>
<td>2050</td>
<td>2050</td>
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</tbody>
</table>
3. RESULTS AND DISCUSSION

Land use change prediction

Most of the hotspots of future land uses are found to occur in the upstream of the basin in Vietnam mainly due to rapid expansion of agriculture. At basin scale, agriculture area will increase from 15.3% in 1997 to 28.1% in 2050. A cross-tabulation of the current and predicted land use maps reveals that an area of future agriculture is converted from thin forest (42%) and grassland (16%).

Water Stress under Different Scenarios

Scenario 1: Upstream area has been identified as a “hotspot” in terms of high WSI level in the dry season although water stress level is considered low at basin scale. There is surplus water in the wet season and water shortage is found in the dry season at both basin and sub-basin scales indicating that assessing water stress at higher spatial and temporal scales may hide water stress at lower scale due to high variations of water availability and demands.

Scenario 2: The variation of projected rainfall in 2050 compared to historical data (1978-2007) results in increasing water resources in the wet season (15%) and decreasing water resources in the dry season (3%) (Fig 2a). Consequently, across the studied basin, average water stress is projected to decrease by 10% and increase by 3% under the AGCM scenario on annual and in the dry season, respectively (Fig 2b).

Scenario 3: There is a slight impact of population growth on decreased future water resources (0.7%). The increasing population results in increasing water stress by 12% across the basin (Fig 2b).

Scenario 4: Although land use/cover change causes increasing surface runoff (1.4%), the increasing of irrigation water demand, and thus reduced water availability (9.1%) overweighs it. The upstream area recently under water stress would be in even more severe situation in 2050 by almost double. Overall, water stress is projected to increase by more than 100% in 2050 (Fig 2b).

Scenario 5: A combination of the three factors causes an overall increase in water stress at basin as well as sub-basin scales, especially in the dry season; and an increased future water stress level is mostly attributed by land use/cover change.

4. CONCLUSIONS

Land use/cover change is found to have the greatest impacts on increased water stress, followed by the population growth; while climate change has slightly effect in reduced future water stress. Combined scenario shows the increasing level of water stress in the future at both basin and sub-basin scales, especially in the dry season.

Figure 2. Percent changes of water resources (a) and WSI (b).

REFERENCES