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*Research Article*

# Future Inflow under Land Use and Climate Changes and Participation Process into the Medium-Sized Reservoirs in Thailand

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The rainfall and runoff within a watershed area upper reservoir are necessary data for reservoir operation. In this manner, climate and land use changes are legitimately affected to inflow trademark into the reservoir storage. This investigation expects to appraise future inflow under the effect of atmosphere and land use changes of the Huay Sabag and Huay Ling Jone reservoirs, Thailand, during the period 2018–2067. The future inflow was evaluated by utilizing the SWAT model with the PRECIS territorial atmosphere model of B2 emanation situation, and considering land use information from the CA Markov model, both the balanced land use by support procedure type, and then unbalanced sort. Land use from CA Markov was adjusted by participation decides based on Taro Yamane table at the 90% of confidence. The outcome found that the normal precipitation and temperature were expanded in both upper store regions. The biggest land use change demonstrated the extension of the sugarcane and Para rubber tree, while paddy field and forest regions were diminished. The normal future inflows into the store under the two cases were expanded in examination with the watched information during the pattern year. However, the future inflow from the case of using CA Markov adjusting by participation process was higher than the future inflow from another case of using CA Markov without participation adjusting insignificantly for both reservoirs.

## 1. Introduction

Water is very important for living both directly and indirectly. Nowadays, many problems relate to water resources including flood and drought problems, and there is a tendency to increase damage to both the economy and society at large. In general, these problems are affecting global climate change [1, 2] and land use change [3–5]. This is due to the rapid increase in population and the need for residential areas or even agriculture, industry, transportation, etc. An estimation of the inflow into a reservoir that includes land use and climate changes in the upper watershed area is an important issue for improvement reservoir operation [6–8].

An estimation of future land use which affects the runoff in a watershed area of a reservoir often uses the CA Markov model (Cellular Automata and Markov Chain). CA Markov is a model utilized for basic leadership which joins parts of Cellular Automata (CA) and Markov Chain that is utilized to foresee land use and land spread change [9, 10]. CA Markov has been connected to an assortment of water asset issues, for example, overflow examination from quick environmental change and urbanization, flood assessment, and soil disintegration [11, 12]. Moreover, the CA Markov model has been connected to foresee land use changes later on [13, 14]. However, future land use is required to approve by participation process of stakeholder for accepting and increasing accuracy.

Participation of stakeholder in water resources management enhances to accept irrigation plan and implement policy [15–17]. The land cover changes in upper watershed effected to streamflow data [18]. An estimation of future environmental change regularly utilizes the PRECIS model. The PRECIS model is a provincial atmosphere model (RCM) which is created by the Hadley Center for Climate Prediction and Research. The point is to investigate the atmosphere later on utilizing information from the worldwide atmosphere model dataset ECHAM4 as a base for computation [19, 20]. The model has a spatial goal of 0.22°C in the matrix and is downscaled to 0.2°C [21]. Abridgment has been generally used to examine environmental change that influences hydrologic frameworks [22, 23].

For the most part, an estimation of inflow frequently utilizes the SWAT model (Soil and Water Assessment Tool). SWAT is a hydrological model that was intended to survey the effect on water assets of precipitation and land use changes, which works on a day-by-day time step. Furthermore, it can likewise work viably with negligible information, which is especially reasonable for territories that have restricted default information [24]. The hydrological SWAT model has been utilized broadly to examine the inflow of little stream bowl [25–29]. The aftereffects of the hydrological SWAT model make it conceivable to perceive future patterns in the inflow into the supply, which has the impact of empowering the forecast of the storm activity later on. The estimation of future inflow into the repository has been examined [30]; in any case, the investigation considered just environmental change and land use change without cooperation in land use change. Interest procedure is significant for water asset the board.

This investigation assessed future inflow into the repository utilizing the SWAT hydrologic model under atmosphere and land use changes. The future land use in the upstream watershed region of the store was outlined utilizing a CA Markov model with interest process and selection sampling data based on Taro Yamane table [31]. The atmosphere influence will be broke down utilizing a PRECIS model under emanation condition B2. The Huay Sabag and Huay Ling Jone reservoirs which are situated in the Northeast of Thailand were used in this examination.

## 2. Materials and Methods

*2.1. Study Area.* The study area was an irrigation project in Yasothorn Province located in the northeast of Thailand in the branches of the Moon River basin. The two suppliers were chosen for the cases study were the Hauy Ling Jone repository and the Hauy Sabag supply which are medium estimated repositories (stockpiling under 100 MCM). The examination zone is depicted in Figure 1. Topographically, the all-out zone of the Huay Sabag is roughly 48.11 $km^2$ with a complete combined yearly normal overflow of about 22.4 MCM during 1996 to 2017 (22 years) and its typical stockpiling limit is 30.03 MCM. The Huay Ling Jone supply has a water system zone of 53.44 $km^2$, full stockpiling limit of repository 21.06 MCM, and dead stockpiling limit of 0.40 MCM. The memorable inflow information records of the Huay Ling Jone repository were recorded from 1994 to 2017 (24 years). Basically, the demands of the downstream water are local consumption, an irrigation system, flood control, domestic water supply, and environmental conservation.

*2.2. Estimation of Future Land Use.* Land use data in the years 2010 and 2015 were used as the baseline for creating future land use in the watershed area. In this study, land use types were classified into 9 types as shown in Figures 2 and 3. The land use in baseline year was input into the CA Markov to generate future land use for five time periods such as 2018–2024, 2025–2038, 2039–2052, 2053–2066, and 2067.

*2.3. Estimation of Future Land Use by Participation Process.* The surveying was conducted by selecting a random number of respondents in the upper watershed area. The number of respondents was calculated by using Taro Yamane formula [31] as presented in equation (1), with a 90% confidence level and a sampling error tolerance level of 10%.

$$n = \frac{N}{1 + (N * e^2)}, \tag{1}$$

where $n$ = sample size, $N$ = total population, and $e$ = level of precision at 90% confidence interval.

*2.4. Simulated Future Climate Scenarios.* The future climate scenarios were simulated from 2018–2067. The study area is located at 16°24′N104°48′E and 16°12′N104°12′E, as presented in Figure 1. The change factor (CF) was used to reduce the tolerances of the PRECIS model that considered the average proportion and difference value between the monthly climate of the record station and the model output [32]. The CF details for rainfall and temperature are described in (2) and (3), respectively:

$$PC_{sim,f-rev} = PC_{sim,f} \times \left(\frac{PC_{obs,b}}{PC_{sim,b}}\right), \tag{2}$$

$$T_{sim,f-rev} = T_{sim,f} - \left(T_{sim,b} - T_{obs,b}\right), \tag{3}$$

where $PC_{sim,f-rev}$ is adjusted future rainfall from PRECIS, $PC_{sim,f}$ is unadjusted future rainfall from PRECIS, $PC_{obs,b}$ is average rainfall of baseline year for record station, $PC_{sim,b}$ is average rainfall of baseline year from PRECIS, $T_{sim,f-rev}$ is adjusted future temperature from PRECIS, $T_{sim,f}$ is unadjusted future temperature from PRECIS, $T_{sim,b}$ is average temperature of baseline year from PRECIS, and $T_{obs,b}$ is average temperature of baseline year from record station.

*2.5. Application of SWAT to Estimate Future Inflow.* The SWAT model requires spatial input data, as described in Table 1. The viability of the estimation was considered by looking at between the inflow from the record station and the inflow from the SWAT model as present as far as $R^2$ (coefficient of

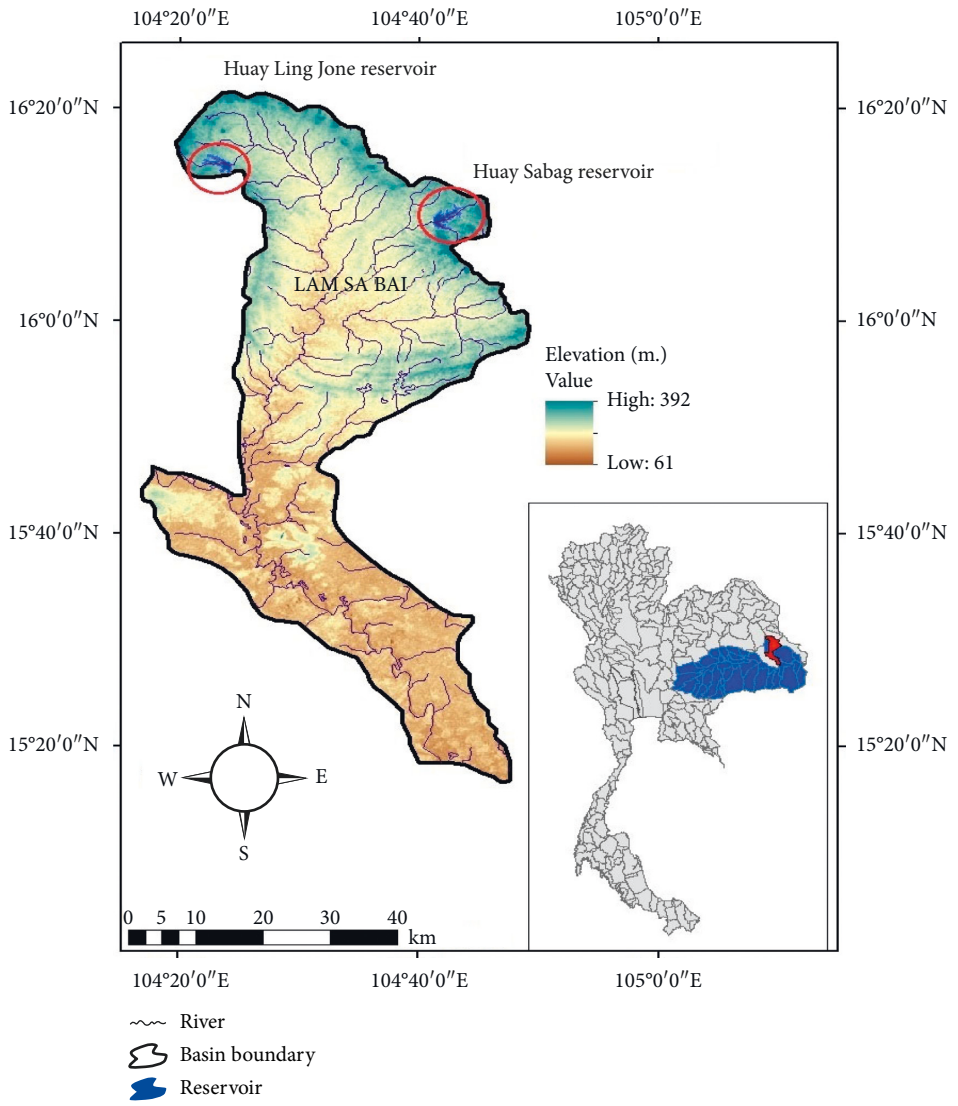



Figure 1: Map of the study area.

assurance), *RE* (relative blunder), and $E_{ns}$ (Nash–Suttclife re-enactment proficiency). By and large, alignment of the SWAT model is finished by changing the hydrologic parameters, and there are eight parameters: Alpha_BF, Gwqmn, Gw_Revap, Sol_Awc, Epco, Esco, Ch_N2, and Gw_delay.

The reasonably aligned SWAT model with the hydrologic parameters, as contrasted, and the record information will be utilized to conjecture future overflow. At that point, the reproduced day by day information from the PRECIS model and future land use from the CA Markov were utilized in the SWAT model to appraise future spillover. The durations for the calculations were separated into five time periods as shown in Table 2. The steps in the calculation are shown in Figure 4.

## 3. Results and Discussion

### 3.1. Land Use Change

*3.1.1. Land Use Change for Validation Processes.* Accuracy validation results of the 2017 map of Huay Sabag and Huay Ling Jone reservoirs were performed by importing the map from actual and simulated map of 2017. This will evaluate the accuracy of the results of the pixel on the map calculated from the simulated and the actual maps by regressive analysis. The results are shown in Table 3 and Figures 5 and 6. It can be seen that the model is highly effective in land use prediction. It is appropriate to predict land use changes in the year 2067.

*3.1.2. Land Use Change in the Future Period.* Future land use maps were reproduced with the CA Markov for the period 2018–2067 and contrasted with the standard times of 2010 and 2015. The biggest land use changes demonstrated developments of sugarcane and Para rubber trees, while paddy field and forest regions were diminished, and the land use patterns have appeared in Tables 4 and 5 and Figures 7 and 8. Five reenacted land use maps demonstrating the change territory are introduced in Figures 9 and 10 for the Huay Sabag and the Huay Ling Jone areas, respectively.

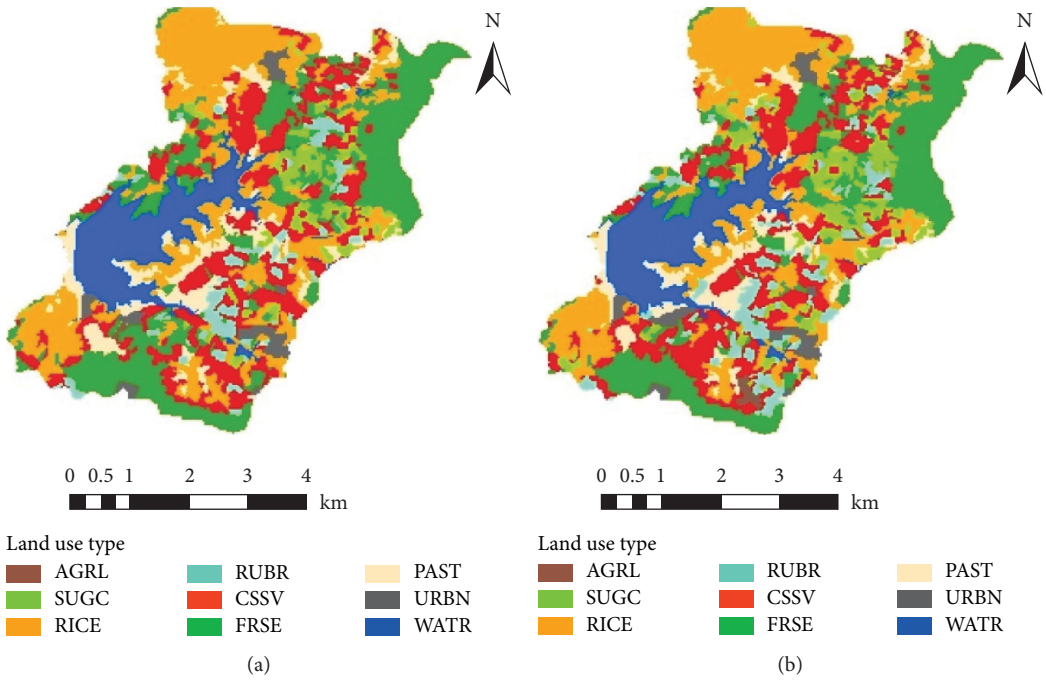



Figure 2: Huay Sabag baseline land use maps: (a) year 2010 and (b) year 2015.

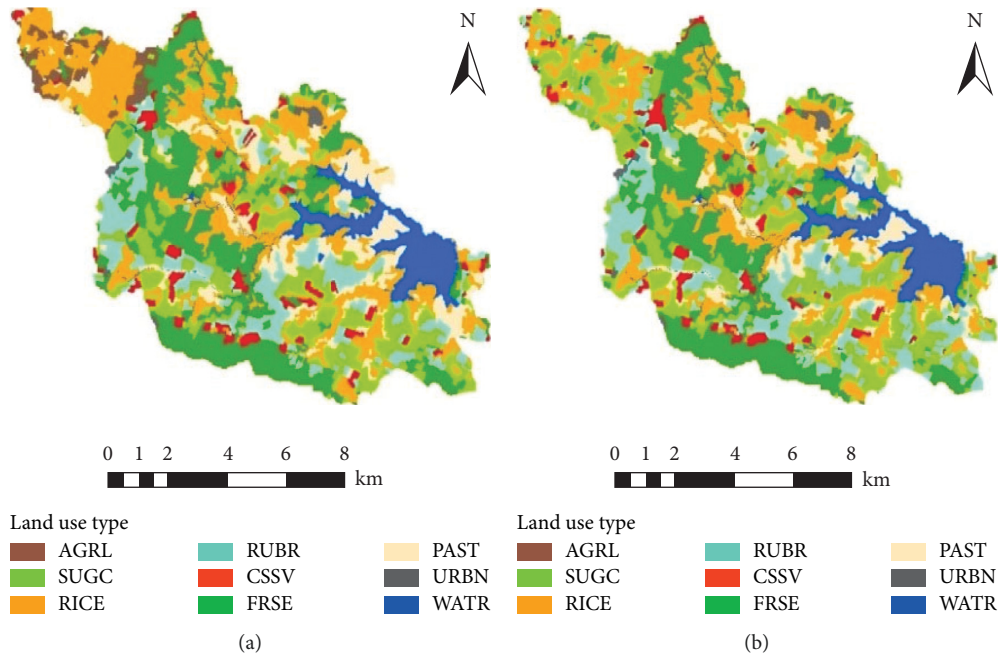



Figure 3: Huay Ling Jone baseline land use maps: (a) year 2010 and (b) year 2015.

*3.1.3. Land Use Change in Future Period by Participation Process.* When bringing the base year map through the participation process in Tables 6 and 7 and simulated in the Markov model, the results found that the largest land use changes showed expansions of sugarcane and Para rubber trees, while paddy field and forest areas were decreased, and the land use trends are shown in Tables 8 and 9 and Figures 11 and 12. Five simulated land use maps showing the transition area are presented in Figures 13 and 14.

### 3.2. Climate Change Scenarios

*3.2.1. Climate Scenarios for Calibration and Validation Processes.* The output results of the climate scenarios from PRECIS for calibration and validation are presented in Table 10 and Figure 15. These results are shown in terms of precipitation, maximum temperature (TX), and minimum temperature (TN) with $R^2$ from before adjustment, calibration, and validation. They indicated that the $R^2$ before

Table 1: Spatial input data for SWAT model.

| Data types | Period | Scale | Source |
|---|---|---|---|
| Spatial data (model input) | | | |
| DEM | 2011 | 30 × 30 m | LDD LDD LDD LDD |
| River map | 2011 | 1 : 50,000 | |
| Soil types | 2011 | 1 : 50,000 | |
| Land use map | 2015 | 30 × 30 m | |
| Climate | 1997–2017 | Daily | TMD |
| Observed runoff (model performance assessment) | | | |
| Huay Sabag | 1996–2017 | Daily | RID |
| Huay Ling Jone | 1994–2017 | Daily | RID |

LDD: Land Develop Department (Thailand). TMD: Thai Meteorological Department. RID: Royal Irrigation Department (Thailand).

Table 2: Future time periods.

| Climate data (years) | Land use map | Future runoff (years) |
|---|---|---|
| 2018–2024 | Map 1, 2024 | 2018–2024 |
| 2025–2038 | Map 2, 2038 | 2025–2038 |
| 2039–2052 | Map 3, 2052 | 2039–2052 |
| 2053–2066 | Map 4, 2066 | 2053–2066 |
| 2067 | Map 5, 2067 | 2067 |

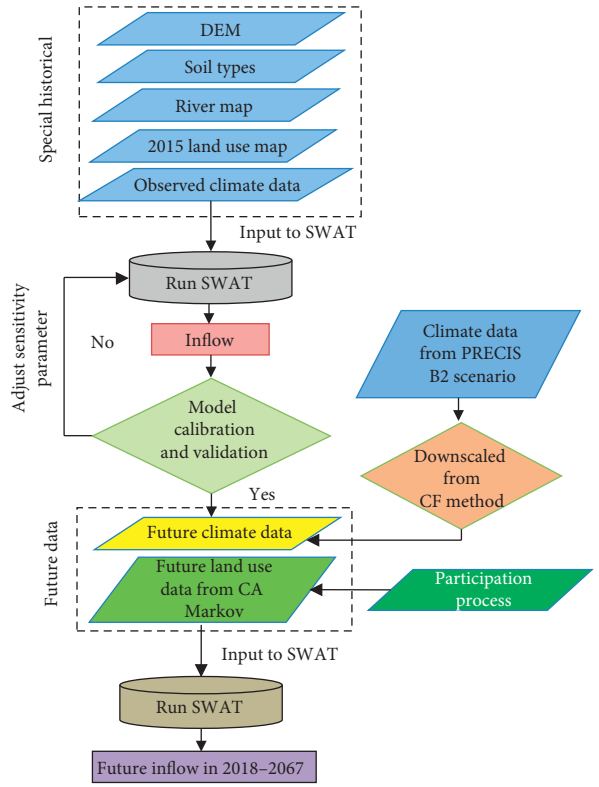



Figure 4: Study schematic of calculation steps for future inflow forecasting.

Table 3: The validation results of maps simulated by CA Markov.

| Area | $R^2$ |
|---|---|
| Hauy Sabag reservoir | 0.90 |
| Huay Ling Jone reservoir | 0.91 |

adjustment was too low, whereas $R^2$ from the calibration and validation process was higher than 0.75 and accepted for this study.

The results also show that the precipitation and temperature from the PRECIS model were close to those of the

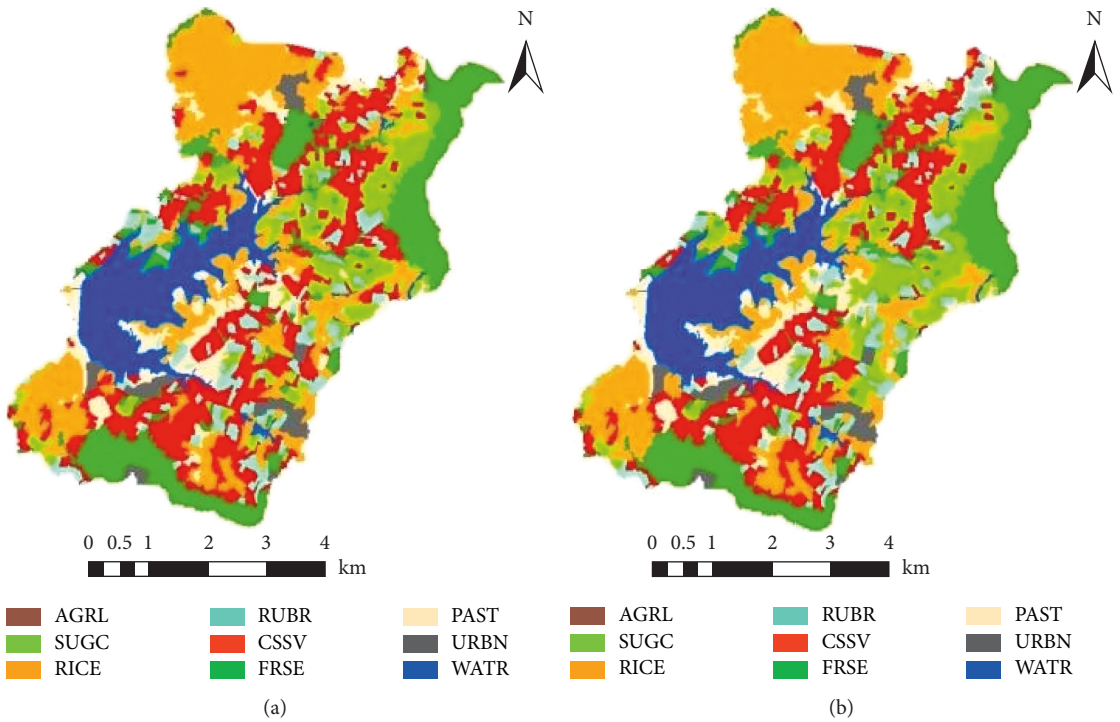



Figure 5: The validation results of actual land use (a) and simulated land use (b) for the Huay Sabag area.

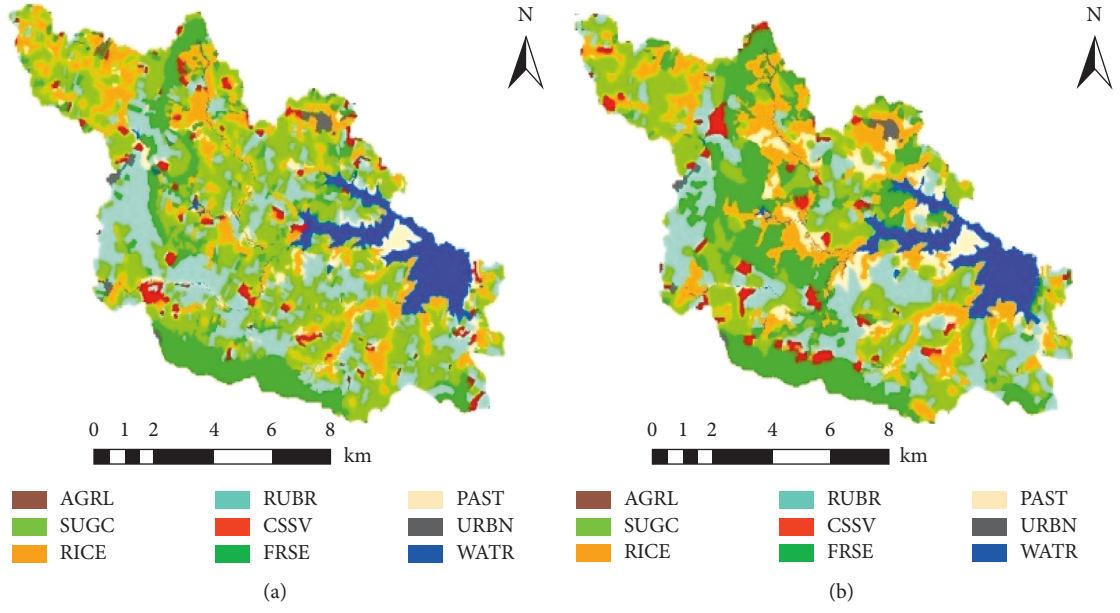



Figure 6: The validation results of actual land use (a) and simulated land use (b) for the Huay Ling Jone area.

record stations. These show that the adjusted PRECIS model can be used to predict the future climate in the next steps.

*3.2.2. Future Climate Scenarios.* The calculated future climates for emission scenarios B2 during 2018–2067 are presented in Figure 16. They indicated that the trend in rainfall during the years 2025–2052 will be lower than the baseline year data. Then, the average rainfall will be higher than the baseline year.

*3.3. Effectiveness of SWAT Model.* The viability of the SWAT model assessed information from two stations (Huay Sabag station and Huay Ling Jone) during 1997–2014. The eight affectability parameters for the model were balanced

Table 4: Trends of land use change for baseline and future periods above the Huay Sabag area ($km^2$).

| Land use types | Baseline land use | | Future land use | | | | |
|---|---|---|---|---|---|---|---|
| | 2010 | 2015 | 2024 | 2038 | 2052 | 2066 | 2067 |
| Agricultural | 0.22 | 0.17 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |
| Sugarcane | 3.63 | 5.35 | 6.02 | 8.35 | 10.11 | 11.35 | 12.99 |
| Rice | 11.57 | 11.04 | 10.98 | 9.77 | 8.15 | 7.18 | 5.95 |
| Rubber | 3.04 | 4.18 | 5.18 | 6.79 | 8.06 | 9.02 | 9.51 |
| Cassava | 8.60 | 6.36 | 5.29 | 4.06 | 3.27 | 2.13 | 1.49 |
| Forest | 10.72 | 10.71 | 10.71 | 10.70 | 10.61 | 10.60 | 10.57 |
| Pasture | 3.50 | 3.37 | 2.95 | 1.46 | 0.91 | 0.83 | 0.61 |
| Urban | 1.27 | 1.33 | 1.33 | 1.33 | 1.33 | 1.33 | 1.33 |
| Water | 5.58 | 5.60 | 5.60 | 5.60 | 5.60 | 5.60 | 5.60 |

Table 5: Trends of land use change for baseline and future periods above the Huay Ling Jone area ($km^2$).

| | Baseline land use | | Future land use | | | | |
|---|---|---|---|---|---|---|---|
| | 2010 | 2015 | 2024 | 2038 | 2052 | 2066 | 2067 |
| Agricultural | 1.47 | 1.22 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 |
| Sugarcane | 8.50 | 9.81 | 9.98 | 10.88 | 12.20 | 12.39 | 13.14 |
| Rice | 13.18 | 13.05 | 13.15 | 12.41 | 11.07 | 10.76 | 10.34 |
| Rubber | 6.12 | 6.81 | 7.03 | 7.81 | 8.69 | 9.60 | 10.15 |
| Cassava | 2.01 | 2.03 | 2.06 | 1.83 | 1.80 | 1.76 | 1.62 |
| Forest | 11.71 | 11.52 | 12.02 | 11.38 | 11.14 | 11.03 | 10.88 |
| Pasture | 6.27 | 4.83 | 5.01 | 4.94 | 4.36 | 3.71 | 3.12 |
| Urban | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 |
| Water | 3.83 | 3.84 | 3.83 | 3.84 | 3.84 | 3.84 | 3.83 |

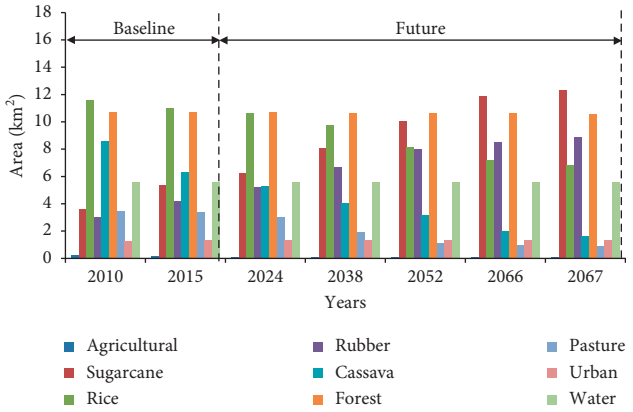



Figure 7: Historical and simulated land use areas above the Huay Sabag area.

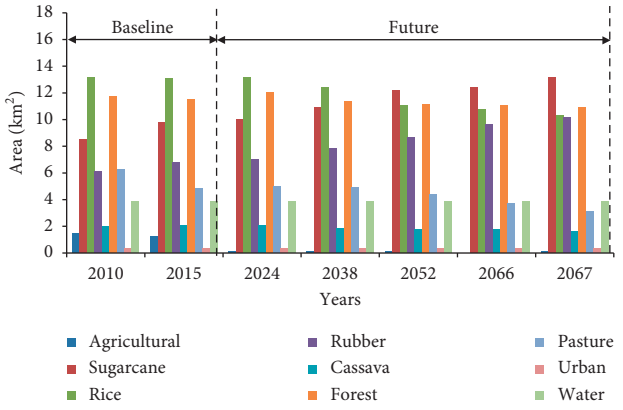



Figure 8: Historical and simulated land use areas above the Huay Ling Jone area.

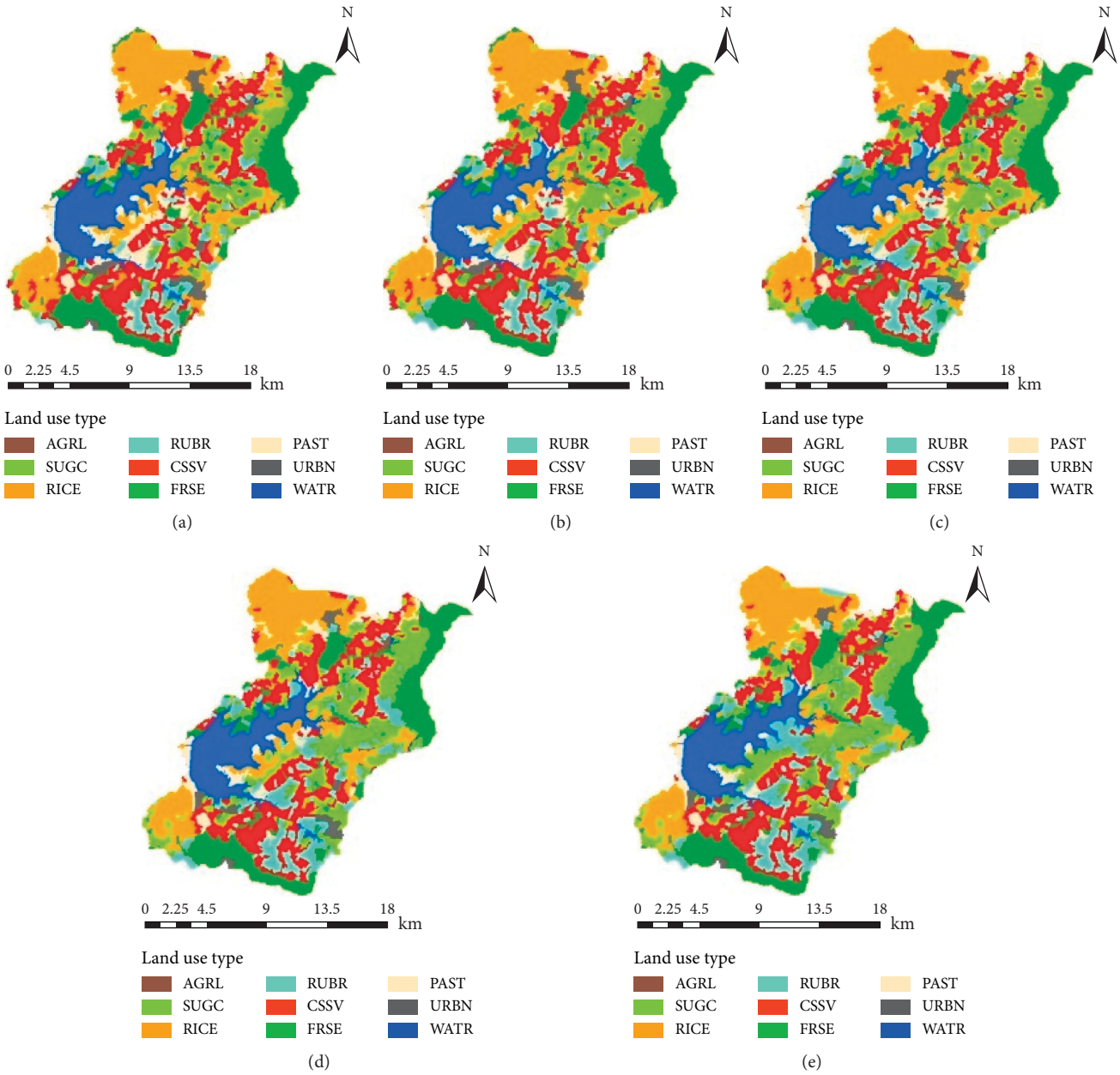



Figure 9: Simulated land use maps for 2018–2067 above the Huay Sabag area. (a) Year 2024. (b) Year 2038. (c) Year 2052. (d) Year 2066. (e) Year 2067.

utilizing manual alignment for each station until powerful records were fulfilled and acknowledged. The acknowledged compelling files are introduced in Table 11. These outcomes demonstrate that the spillover from the SWAT model was near the recorded overflow generally. The runoff from the SWAT model and runoff from the record stations provided that the effective indexes ($R^2$, $RE$, and $E_{ns}$) could be accepted, as shown in Table 12 and Figure 17.

*3.4. Estimation of Future Inflow.* The calibrated SWAT was used to simulate with contributions from the anticipated atmosphere information from PRECIS, which likewise had decreased resistances and the anticipated land use maps from the CA Markov model. The evaluated future inflow into the Huay Sabag and Huay Ling Jone repositories was considered for the years during 2018–2067. The reproduced outcomes uncover that the normal yearly future inflow into the Huay Sabag supply utilizing CA Markov without altering area use and changing area use by interest procedure was 24.79 and 24.68 MCM stores separately. Though, the normal yearly future inflow into the Huay Ling Jone supply utilizing CA Markov without altering area use and changing area use by investment procedure was 24.14 and 24.15 MCM separately. Figures 18–21 show the future inflows into the Huay Sabag reservoir were increased during 2018–2024 and decreased during 2025–2052 and then increased during 2053–2067, whereas the future inflows into the Huay Ling

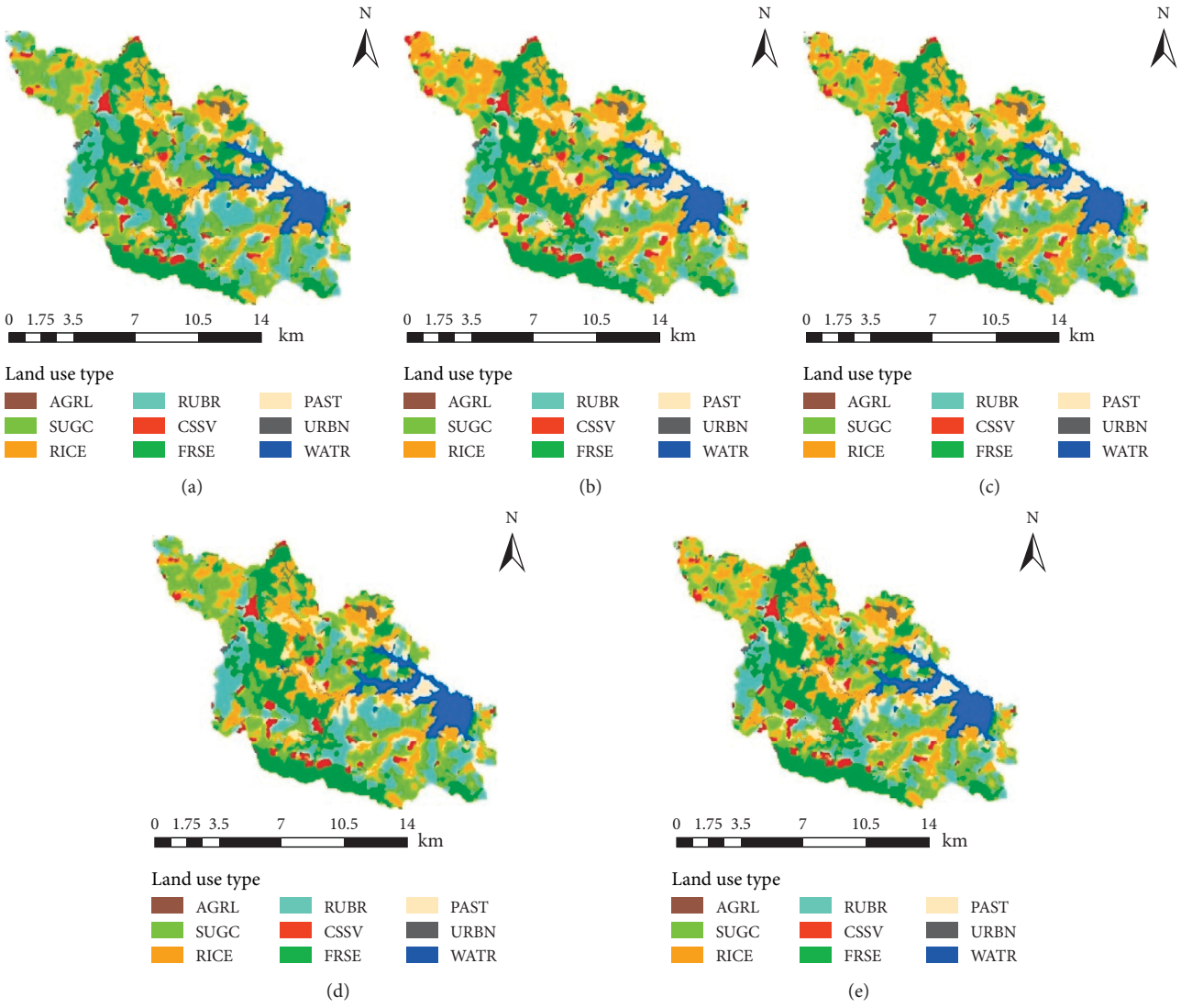



Figure 10: Simulated land use maps for 2018–2067 above the Huay Ling Jone area. (a) Year 2024. (b) Year 2038. (c) Year 2052. (d) Year 2066. (e) Year 2067.

Table 6: The population and sample used in the study of the Huay Sabag.

| Subdistrict | Village | Population | Sample |
|---|---|---|---|
| Bung Kha | Nomkao, 11 | 162 | 38 |
| | Chongmek, 16 | 181 | 43 |
| | Nomkao, 17 | 171 | 40 |
| Total | | 514 | 120 |

Table 7: The population and sample used in the study of the Huay Ling Jone.

| Subdistrict | Village | Population | Sample |
|---|---|---|---|
| Hongsang | Dongyang, 16 | 217 | 46 |
| | Hongsang, 17 | 217 | 46 |
| | Hongsang, 17 | 130 | 28 |
| Total | | 564 | 120 |

Table 8: Trends of land use change for baseline and future periods above the Huay Sabag area ($km^2$) by participation process.

| Land use types | Baseline land use | | Future land use | | | | |
|---|---|---|---|---|---|---|---|
| | 2010 | 2015 | 2024 | 2038 | 2052 | 2066 | 2067 |
| Agricultural | 0.22 | 0.17 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |
| Sugarcane | 3.63 | 5.35 | 6.25 | 8.09 | 10.02 | 11.92 | 12.30 |
| Rice | 11.57 | 11.04 | 10.66 | 9.77 | 8.15 | 7.18 | 6.83 |
| Rubber | 3.04 | 4.18 | 5.20 | 6.65 | 8.03 | 8.49 | 8.88 |
| Cassava | 8.60 | 6.36 | 5.31 | 4.03 | 3.19 | 1.98 | 1.63 |
| Forest | 10.72 | 10.71 | 10.71 | 10.67 | 10.61 | 10.60 | 10.57 |
| Pasture | 3.50 | 3.37 | 3.00 | 1.91 | 1.12 | 0.95 | 0.90 |
| Urban | 1.27 | 1.33 | 1.33 | 1.33 | 1.33 | 1.33 | 1.33 |
| Water | 5.58 | 5.60 | 5.60 | 5.60 | 5.60 | 5.60 | 5.60 |

Table 9: Trends of land use change for baseline and future periods above the Huay Ling Jone area ($km^2$) by participation process.

| Land use types | Baseline land use | | Future land use | | | | |
|---|---|---|---|---|---|---|---|
| | 2010 | 2015 | 2024 | 2038 | 2052 | 2066 | 2067 |
| Agricultural | 1.47 | 1.22 | 0.22 | 0.01 | 0.01 | 0.01 | 0.01 |
| Sugarcane | 8.50 | 9.81 | 9.92 | 11.26 | 11.65 | 12.50 | 13.05 |
| Rice | 13.18 | 13.05 | 13.08 | 11.06 | 10.75 | 10.29 | 9.77 |
| Rubber | 6.12 | 6.81 | 7.82 | 8.80 | 9.14 | 10.03 | 11.08 |
| Cassava | 2.01 | 2.03 | 1.93 | 1.92 | 1.73 | 1.65 | 1.63 |
| Forest | 11.71 | 11.52 | 11.49 | 11.58 | 11.49 | 10.96 | 10.71 |
| Pasture | 6.27 | 4.83 | 4.80 | 4.64 | 4.48 | 3.81 | 3.00 |
| Urban | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 |
| Water | 3.83 | 3.84 | 3.83 | 3.84 | 3.84 | 3.84 | 3.84 |

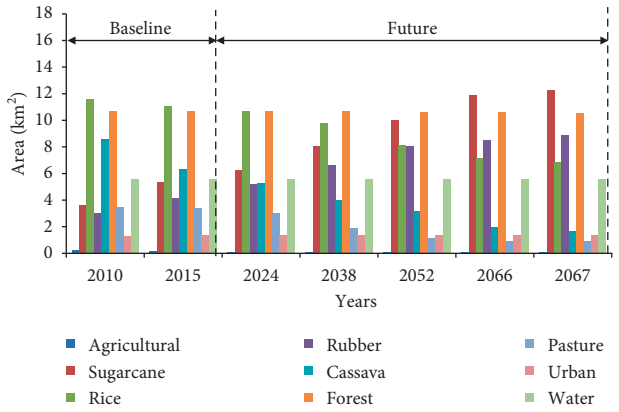



Figure 11: Historical and simulated land use areas above the Huay Sabag area by participation process.

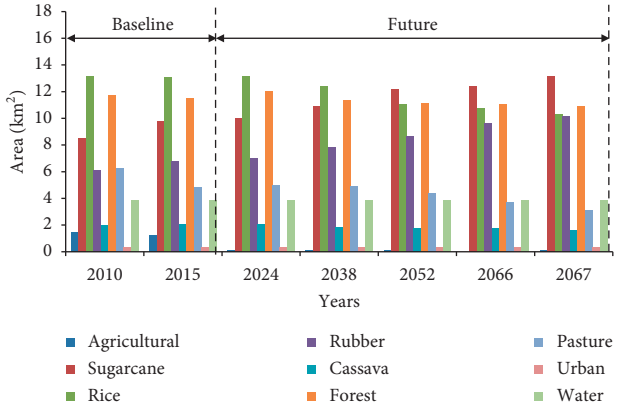



Figure 12: Simulated land use maps for 2018–2067 above the Huay Ling Jone area by participation process.

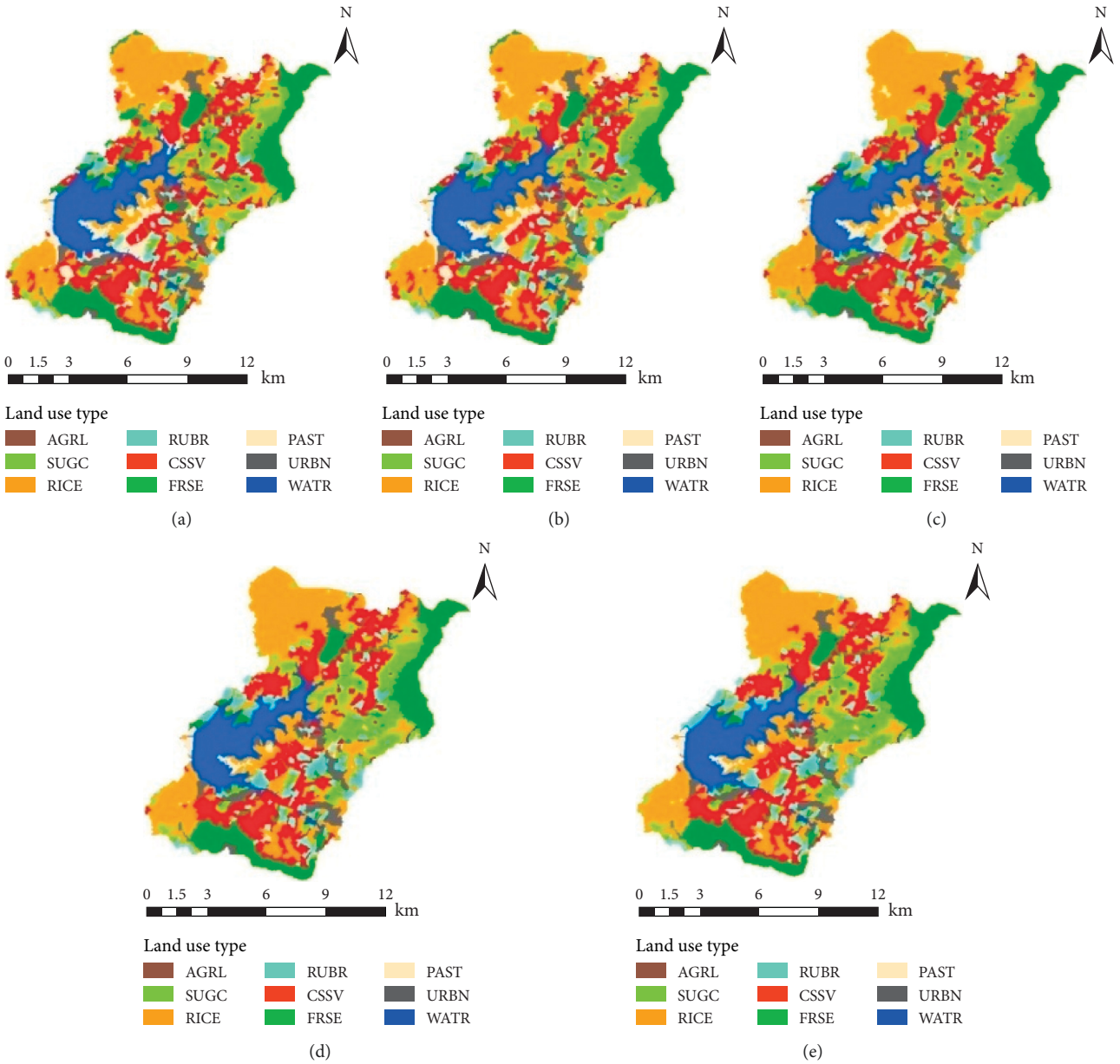



Figure 13: Historical and simulated land use areas above the Huay Sabag area by participation process. (a) Year 2024. (b) Year 2038. (c) Year 2052. (d) Year 2066. (e) Year 2067.

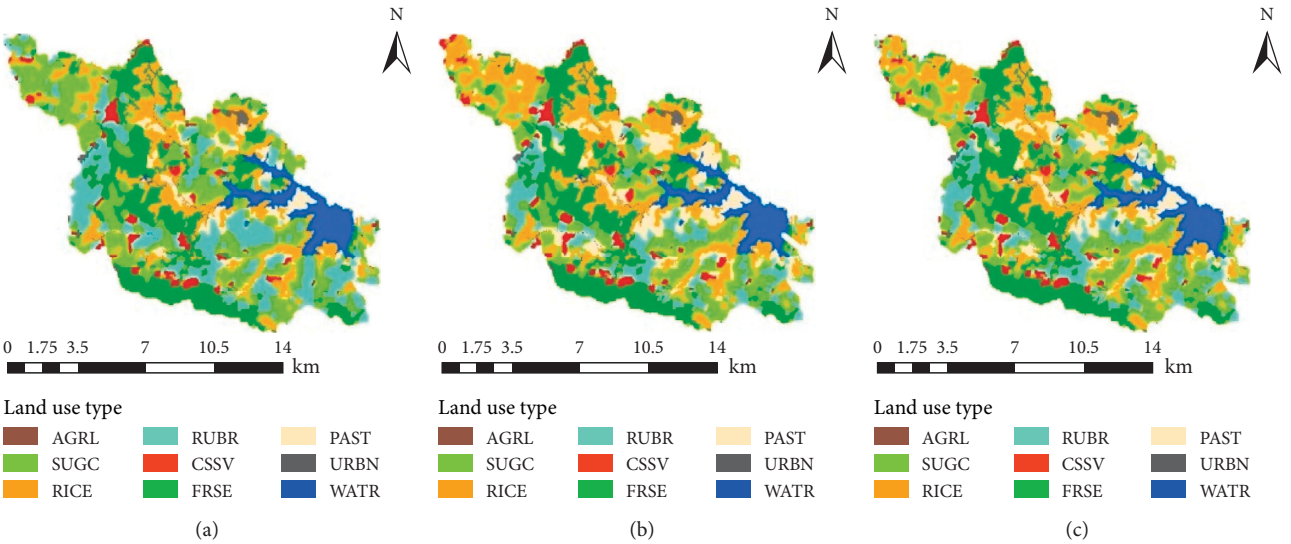



Figure 14: Continued.

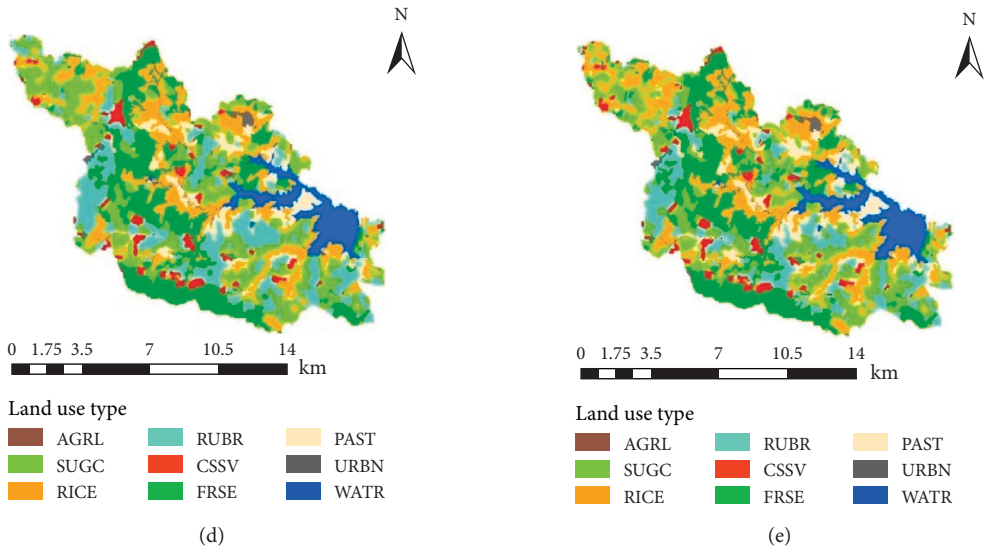
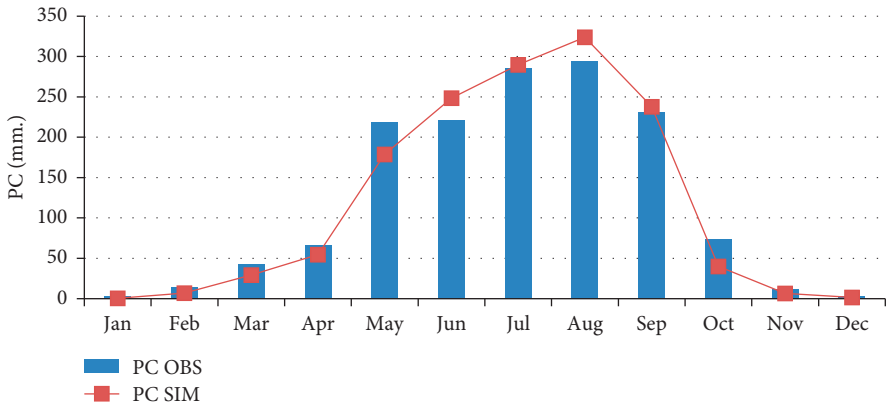



Figure 14: Simulated land use maps for 2018–2067 of the Huay Ling Jone by participation process. (a) Year 2024. (b) Year 2038. (c) Year 2052. (d) Year 2066. (e) Year 2067.

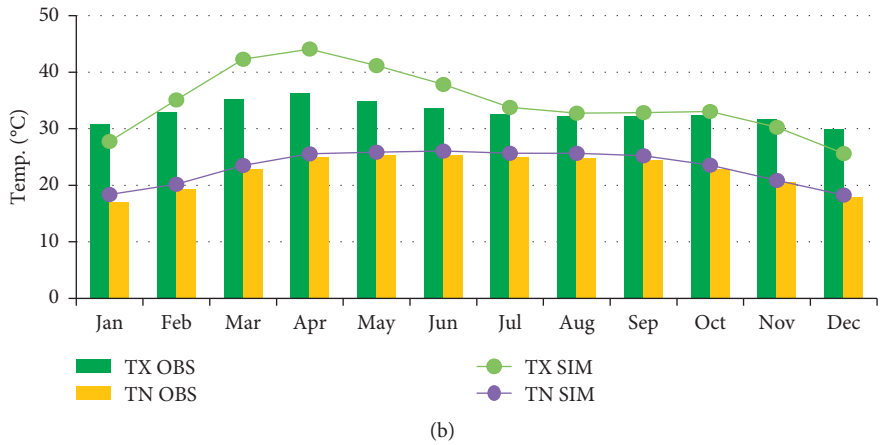
Table 10: $R^2$ of climate scenarios.

| Case | Station | $R^2$ before adjustment | Calibration | | Validation | |
|---|---|---|---|---|---|---|
| | | | Years | $R^2$ | Years | $R^2$ |
| Precipitation (PC) | | | | | | |
| B2 | Mukdahan | 0.65 | 1997–2011 | 0.77 | 2012–2017 | 0.77 |
| Maximum temperature (TX) | | | | | | |
| B2 | Mukdahan | 0.54 | 1997–2011 | 0.75 | 2012–2017 | 0.76 |
| Minimum temperature (TN) | | | | | | |
| B2 | Mukdahan | 0.69 | 1997–2011 | 0.78 | 2012–2017 | 0.76 |



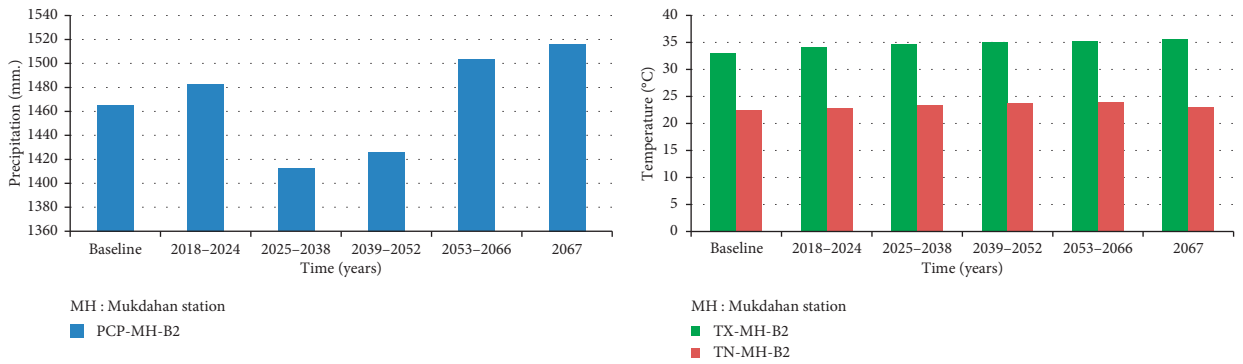

(a)

Figure 15: Continued.




(b)

Figure 15: Goodness of fit from observed climate stations and PRECIS data after reduced tolerances for Mukdahan station. (a) PC: B2 scenario. (b) TX and TN: B2 scenario.




(a) (b)

Figure 16: Future climate trends compared to baseline.

Table 11: Accepted effective indexes of sensitivity parameters for four stations.

| No. | Parameter | Description | Range | HSB | HLJ |
|---|---|---|---|---|---|
| 1 | ALPHA_BF | Baseflow alpha factor | 0-1 | 0.9 | 0.9 |
| 2 | GWQMN | Threshold water depth in the shallow aquifer for flow | 0–500 | 1000 | 1000 |
| 3 | GW_REVAP | Water uptake directly from the shallow aquifer by deep tree | 0–500 | 0.10 | 0.18 |
| 4 | CN2 | Initial curve number (II) value | 35–98 | 90 | 80 |
| 5 | SOL_AWC | Available water capacity | 0-1 | 0.9 | 0.1 |
| 6 | EPCO | Plant uptake compensation factor | 0-1 | 0.9 | 0.1 |
| 7 | ESCO | Soil evaporation compensation factor | 0-1 | 0.1 | 0.9 |
| 8 | GW_DELAY | Groundwater delay time | 0–500 | 31 | 31 |

HSB = Huay Sabag station, HLJ = Huay Ling Jone station.

Table 12: Effective indexes of the SWAT model.

| Sta. | Range | Years | Average annual runoff (MCM) | | Assessment index | | |
|---|---|---|---|---|---|---|---|
| | | | Observed | Simulation | $R^2$ | $RE$ | $E_{ns}$ |
| HSB | Calibration | 2005–2011 | 2.135 | 2.052 | 0.76 | 42.95 | 0.71 |
| | Validation | 2017 | 2.714 | 5.263 | 0.78 | 93.92 | 0.56 |
| HLJ | Calibration | 2005–2011 | 2.002 | 3.790 | 0.81 | 89.31 | 0.49 |
| | Validation | 2017 | 3.276 | 4.685 | 0.77 | 43.03 | 0.38 |

HSB = Huay Sabag station, HLJ = Huay Ling Jone station.

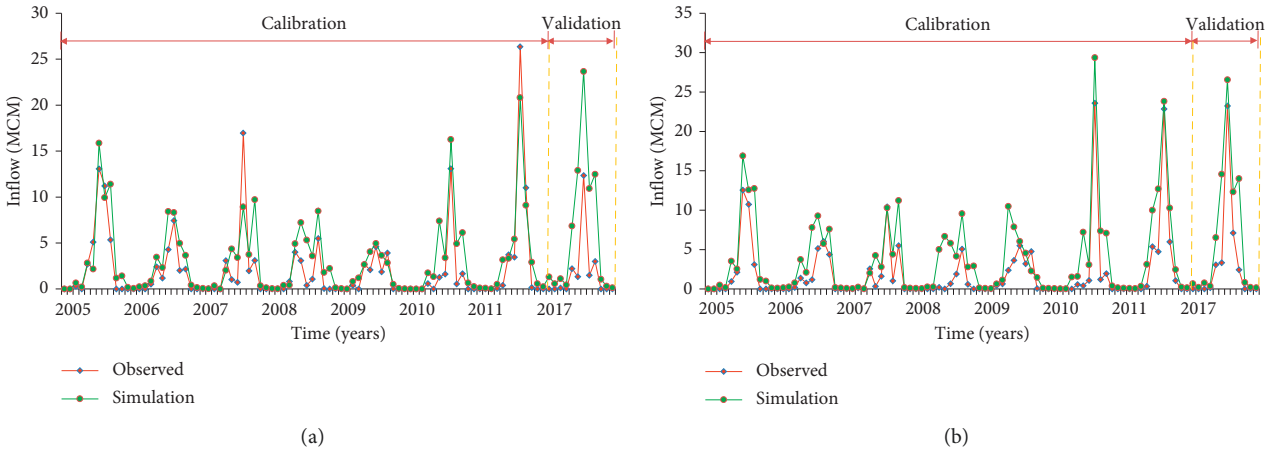



Figure 17: Comparison between inflows from observed stations and SWAT result: (a) Huay Sabag and (b) Huay Ling Jone.

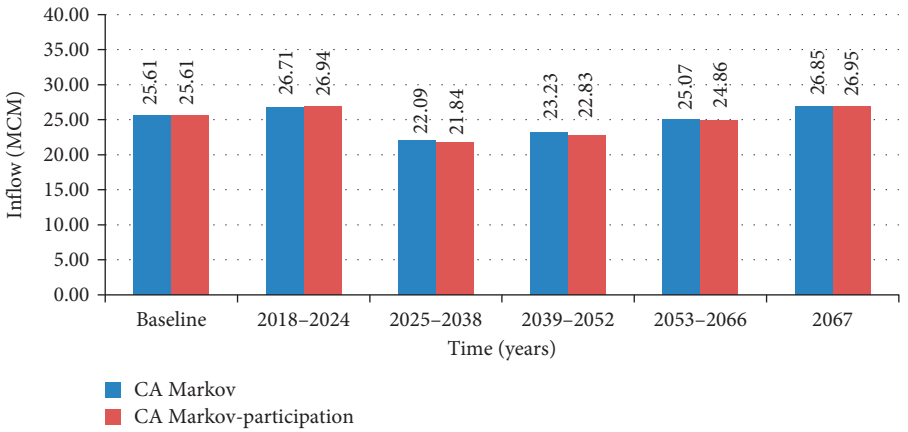



Figure 18: Baseline and future yearly inflow into Huay Sabag reservoir.

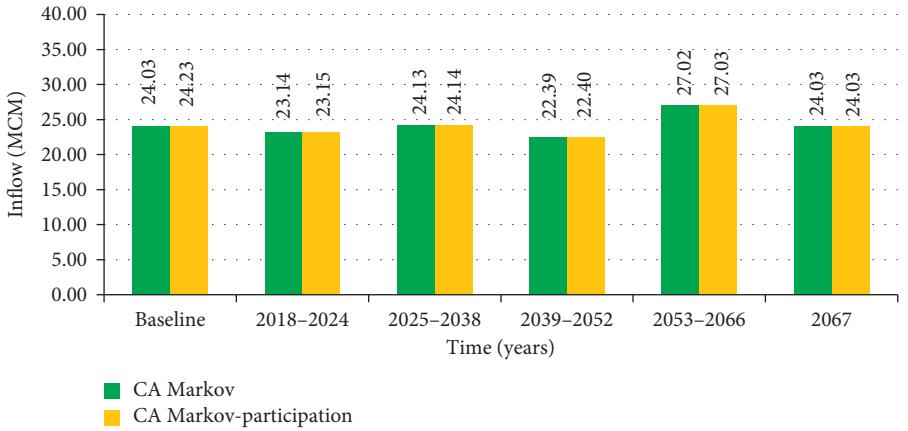



Figure 19: Baseline and future yearly runoff into Huay Ling Jone reservoir.

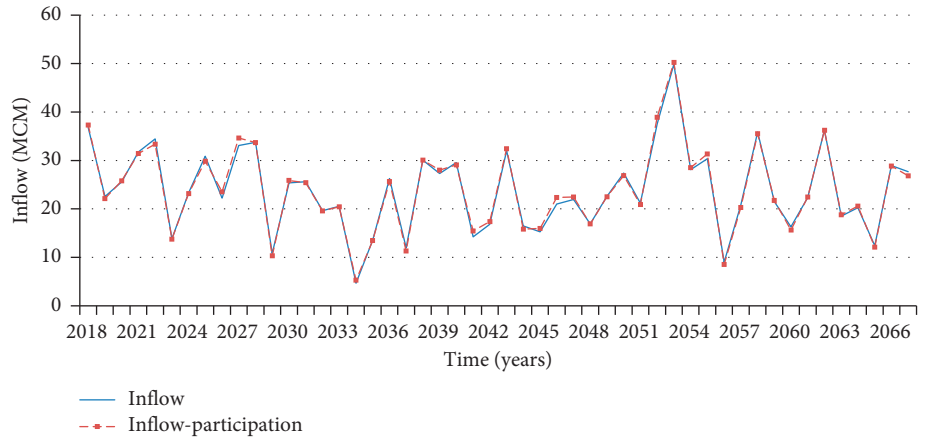



Figure 20: Future runoff into Huay Sabag reservoir.

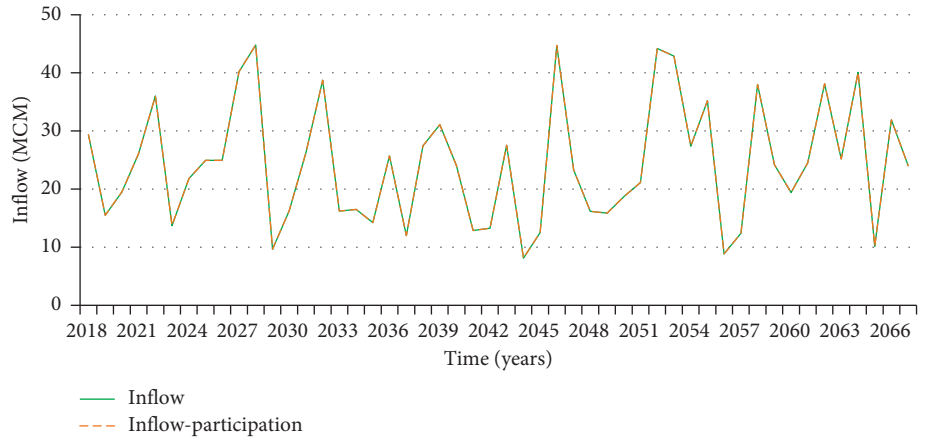



Figure 21: Future runoff into Huay Ling Jone reservoir.

Jone reservoir were slightly decreased during 2018–2024, then slightly increased during 2025–2038, then decreased again during 2039–2052, and increased during 2053–2066 as compared with the baseline inflows.

## 4. Conclusions

This study estimated future inflow into the reservoir by considering the effect of climate and land use changes. The examination territories were store frameworks of the Huay Sabag and the Huay Ling Jone, Yasothorn province, Thailand. The SWAT hydrological model was utilized to assess future inflow. The PRECIS atmosphere model was utilized to speak to the expectation of the B2 situation. The CA Markov model was utilized to gauge land use change upper repository region. The investment procedure was considered for modifying area use change case. The outcomes demonstrated that the evaluated future land-use changes of sugarcane and the urban territory were expanded, which for the most part are secured zones right now utilized for paddy and timberland, by both interest and without investment forms. The normal yearly future inflows into the supply under the B2 situation were expanded from the standard time frame for the two repositories. The results also found that future inflow from the case of using CA Markov with adjusting by participation process was higher than the future inflow without adjusting the process for both reservoirs insignificantly.

## Data Availability

The figures data used to support the findings of this study are included in the article.

## Conflicts of Interest

The authors declare no conflicts of interest.

## Acknowledgments

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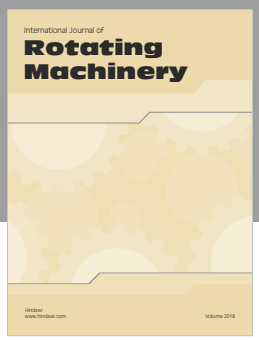

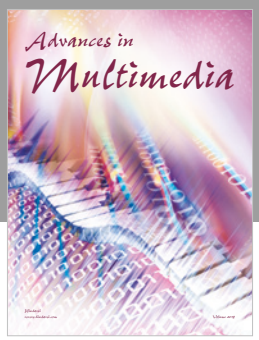

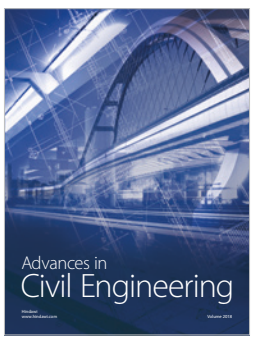

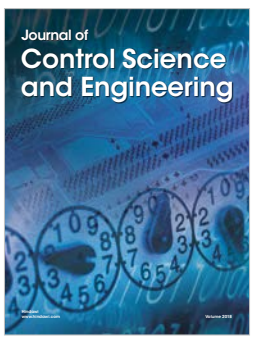

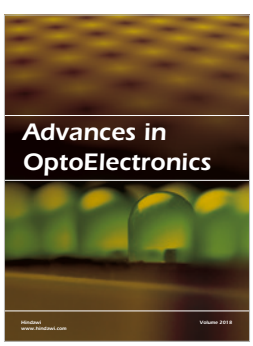

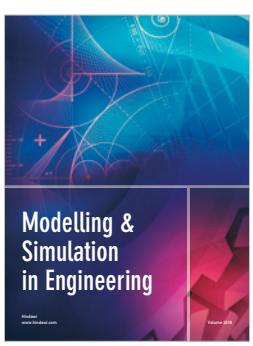

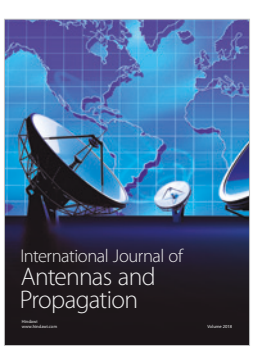

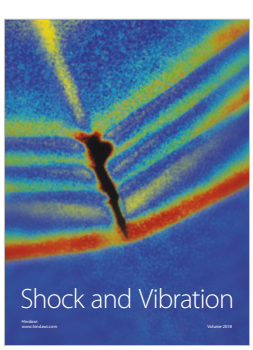

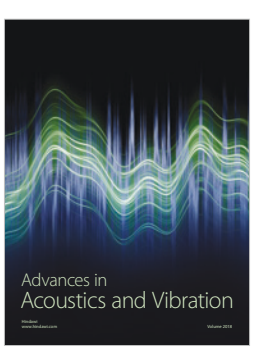

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