Chapter 6
Conclusions and scope for future work

6.1 Conclusions

Producing freshwater by solar still with its simplicity would be one of the best solutions to supply freshwater with limited technical facilities in remote areas, especially in crises. Thermal energy storage (paraffin wax) doped with nanoparticles (CuO) stored in a copper cylinder showed substantial improvement in daily productivity.

Some of the primary objectives of the present study includes:

- Design and fabrication of passive solar still system using multiple phase change materials
- Thermal modelling of developed system
- Energy balance for solar still (for charging and discharging mode)
- Using copper oxide nanoparticle for enhancement of thermal conductivity of energy storage materials for solar still applications
- Economic analysis and marketing entry (commercialization) of solar still as a frugal technology
- Uncertainty analysis for the designed solar still

Based on these objectives the experiments were held, whose results and their discussions were presented in the previous chapters and the important outcomes of the present study have been summarized as follows:

1. Copper cylinders filled with phase change materials integrated above the basin liner improved the productivity of the solar still. Water basin temperature decreases with an increase in water depth using paraffin wax, which is being least affected due to high heat storing capacity as compared to stearic acid and lauric acid.

2. Total distillate decreased linearly with the water depth in all three PCMs. The maximum distillate has been obtained using paraffin wax as compared to stearic acid and lauric acid. This has been due to the high latent heat of capacity of paraffin wax as compared to the other two PCMs.
3. However, lauric acid still also performed well as the other two PCMs when stored in copper cylinder. Cylindrical storage of PCM has rendered better results as compared to spherical storage due to its high surface area.
4. The maximum and average temperature of the water basin has been highest for SSNPCM followed by SSPCM, and SSS.
5. Nanoparticles have nominal effect on the maximum values of the heat transfer coefficients involved between water and glass cover. However, the average values of these heat transfer coefficients throughout the experimental run have been much higher for SSNPCM as compared to SSPCM and SSS.
6. The present study revealed that the evaporative, convective, and radiative heat transfer coefficients increase with an increase in solar intensity. The combination of paraffin wax and nanoparticles increase its thermal conductivity resulting a better heat transfer rate.
7. The copper cylinder containing PCM doped with CuO (nanoparticle) placed above the liner has enhanced the daily productivity of the solar distillation unit
8. Cylindrical copper storage showed better performance as compared to spherical copper storage used for PCM or NPCM, and this improved performance has been due to increased surface area for a given volume. Charging and discharging time for NPCM have been decreased compared to PCM due to their improved thermal conductivity.
9. At present, a traditional desalination system to supply distilled water is enjoying monopoly power as a single service provider in the market. Subsequently, our proposed

novel frugal solar still would enter the market with better technology than that of the traditional. The market structure, due to the entry of our proposed solar still is no longer a monopoly but becomes duopoly in nature.

10. The market price for distilled water under the duopoly market is lower than that of a monopoly. As a result, the total demand for distilled water would be higher in the duopoly market than that of monopoly. Therefore, duopoly with the entry of our proposed solar still would reduce the scarcity of drinking water especially for underserved populations in extreme resource limited settings, and hence, would produce higher welfare to the society than that of monopoly.
11. The traditional desalination system cannot restrict the entry of our proposed solar still into the market. Our proposed solar still always enjoys a higher profit than the traditional desalination system in the duopoly market due to its technological advantages.
12. Our proposed solar still enjoys a higher market share than the traditional desalination system in the duopoly market when the cost of the traditional system is above a threshold level.

6.2 Future scope of work

The future scope of work can be summarized as follows.

1. In the future scope of work, the performance of solar still can further be studied with the variation of copper cylinders arrangement.
2. PCMs with low thermal conductivity can be improved using different nanoparticles and therefore, extensive research on nano-enhanced PCM and its applications in solar till systems is recommended.
3. It is very important to reduce charging and discharging cycle time of PCM and NPCM in order to achieve maximum distillate in solar still systems. However, the thermo-

physical properties and thermo chemical storage methods are equally competitive and further attention is needed in this work.

4. The performance of solar still were affected by the various meteorological parameters such as solar intensity, ambient temperature, wind velocity and relative humidity, and other designed parameters like, depth of water, area of solar still basin, inclination of condensing glass cover and temperature difference between water to glass cover. These factors have to be optimized to enhance the productivity of solar stills.
5. We are establishing the proof of a novel concept regarding integration of PCM doped with nanoparticles and stored in copper cylinders leading to significant enhancement in the solar distillate output of a solar still. However, in the scope of future research, the Technology Readiness Level (TRL) of our proposed solar still would be enhanced for transforming our laboratory scale prototype into the actual scale for further commercialization. The brake even analysis of our product would also be studied.