With increasing urbanization and the impact of global climate change, Southeast Asia faces increasing challenges to provide sufficient, safe and nutritious food to its people in the coming decades. Conscious of these emerging challenges, leaders of Member States of the Association of Southeast Asian Nations (ASEAN) recently laid out their ASEAN Community Vision 2025, which emphasizes the need to develop a food and agriculture sector within ASEAN that is competitive, inclusive, resilient and sustainable, and which ultimately contributes to food and nutrition security for the region.

Recognizing some of these challenges for the region, ILSI Southeast Asia Region and the Genetic Modification Advisory Committee (GMAC) of Singapore organized the Seminar on Challenges for Food and Nutrition Security in Southeast Asia: Opportunities and Challenges for Gene Stacking and Other Plant Breeding Techniques, which was held at the Breakthrough Auditorium, Matrix Building at Biopolis in Singapore on November 20, 2015. Support for the meeting was also provided by the United State Department of Agriculture (USDA) as a collaborator.

To provide an understanding of the overall context underlying the topic of the seminar, the opening presentation on the Challenges for Food and Nutrition Security and the Role to be Played by Crop Improvement was shared by Prof. Paul Teng from Nanyang Technological University in Singapore, who is also the Chairman of GMAC. Prof. Teng explained that with the exception of Brunei and Singapore, Southeast Asian countries are generally regarded as being low in food security, despite them also being major producers of agril-food products such as rice, fruits and vegetables, as well as seafood. This situation is caused by a number of supply and demand factors. On the supply-side, these include a declining and ageing farmer population, deteriorating agricultural performance and unstable crop yields, environmental degradation, as well as climate change; while on the demand side, there is an increasing demand for food due to urbanization and increasing incomes, which has also led to dietary changes that increase the demand for more diverse and high protein foods. One solution that has been put forward to address some of these challenges is through the genetic improvement of food crops, so that they can provide better yields and improved nutrition. Through such genetic improvements, food crops are able to gain resistance to biotic stressors (weeds, insect pests, diseases) and abiotic stressors (drought, flooding and salinity), which would help to increase crop yields. On the other hand, genetic improvements that raise the nutritional quality of food crops can also help to address ongoing nutrition issues, in particular for micronutrient deficiencies.

Following the opening paper, Mr. Ashish Wele from HarvestPlus, which is part of the CGIAR Research Program on Agriculture for Nutrition and Health (A4NH), shared ongoing efforts by HarvestPlus in developing more nutritious food crops, through his paper on Improving Nutrition Quality of Food Crop using Conventional Plant Breeding Techniques – Opportunities and Challenges. Mr. Wele explained that micronutrient deficiencies, such as for Vitamin A, iron and zinc, afflicts many countries particularly in the developing world. The strategies and means available to address this type of ‘hidden hunger’ include direct micronutrient supplementation, commercial fortification of foods, increasing dietary diversity, as well as through agricultural
intervention via biofortification of food crops. In this regard, HarvestPlus is working on the agricultural intervention strategy by developing biofortified staple crops through conventional breeding methods that can provide sources of micronutrients in the diet. The type of biofortified crops released by HarvestPlus in different countries are specifically targeted towards the needs for each country and also take into account the cost-effectiveness such an intervention. Among the crops that have already been rolled out by HarvestPlus include Vitamin A enriched sweet potato in Mozambique and Uganda and iron-fortified pearl millet and wheat in Rajasthan province in India. The biofortification programs implemented by HarvestPlus have so far been very successful, largely because of a holistic strategy that includes the development of the crop, raising awareness and encouraging adoption of the crop by farmers, and finally scaling up and mainstreaming the product through multiple local and international partnerships.

While HarvestPlus primarily uses conventional breeding techniques for biofortification, other organizations such as the International Rice Research Institute (IRRI) have also adopted genetic engineering techniques to do so, such as for the Golden Rice project. Dr. Donald MacKenzie from IRRI shared a presentation on Improving Nutritional Quality of Crops using Genetic Engineering Techniques – Opportunities and Challenges, and explained some of the reasons for applying genetic engineering for biofortification. Dr. Mackenzie shared that genetic engineering techniques can be useful in specific circumstances, such as when the targeted level for a particular nutrient is above the range of natural variation of the nutrient present naturally in the crop species (for e.g. pro-vitamin A, folate and iron in rice); as well as when a particular crop species is difficult to breed through conventional means (for e.g. banana, cassava and potato that are vegetatively propagated). However, in contrast to using conventional breeding methods, the usage of genetic engineering techniques for biofortification comes with additional challenges such as certain unique product development considerations; the need to consider regulatory implications and safety assessment requirements; and the need for public acceptance of foods that have been produced through genetic engineering. In the case of Golden Rice, IRRI has developed a specific regulatory strategy to address these considerations, which includes targeting specific countries for cultivation (Bangladesh, Indonesia and the Philippines); submitting separate applications for food/feed approvals versus cultivation approvals; and implementing efficacy studies only after receiving food/feed approvals. In anticipation of submission for regulatory approvals, the transgenic events contained in golden rice have also been thoroughly characterized to facilitate requirements for safety assessment.

Following the two presentations comparing biofortification using conventional breeding and genetic engineering approaches. Prof. Wayne Parrott from the University of Georgia, USA, shared his views on the overall evolution and development of plant breeding to improve food crops through his presentation on Plant Improvement – Perspectives on Conventional and Genetic Engineering Techniques. Prof. Parrott explained that throughout history, plant breeders have continuously sought to improve plants used for food in order to obtain higher crops yields and to confer resistance against adverse growing conditions. The earliest efforts in plant breeding include the domestication of wild food plants, which have been achieved through the process of selection for desired traits over time. In modern times, plant breeders continue to use this conventional breeding approach of selection to develop modern cultivars that contain desirable traits and often stack or combine these genetic traits to obtain the desired properties. The source of genes that are used for selection often come from wild relatives of domesticated species. During conventional breeding, undesirable traits are often also incorporated into the resulting plant and need to be eliminated through several cycles of breeding to obtain the final desired product. More recently, it has also been discovered that the conventional breeding process also results in the accumulation of new genes in plants, rather than just the replacement
of one form of a gene (allele) with another as previously thought. Apart from using genes found in wild relatives, plant breeders have also adopted the use of radiation to obtain new gene mutations in plants that could provide useful traits that could be selected. However, the final product of such plants obtained through mutational breeding often also incorporates gene mutations caused by exposure to radiation that are not always well characterized. Additionally, plant breeders have also been successful in transferring genes from non-sexually compatible species through the crossing with an intermediate species. This process does however result in the unintended transfer of large segments of DNA apart from the desired gene into the final product, which is a phenomenon known as ‘linkage drag’. Finally, the development of genetic engineering techniques using transgenic technology has provided plant breeders with a more accurate means to transfer desired genes into the final product and it also provides the possibility to transfer genes from any source. When compared with plants bred using conventional breeding and mutation breeding, it has been shown that genetically engineered plants have far less genetic variability, which would mean that they would also have a lower likelihood to produce unintended effects. Hence, stacking of traits from genetically engineered plants would also not likely to cause greater chances for unintended effect as stacking of traits from conventionally bred plants.