through the local level should harmoniously ensure that their fisheries and aquaculture development policies include the need to: encourage optimal use of harvest from capture fisheries; reduce post-harvest losses; and enhance aquaculture benefits by engaging and supporting rural communities in farming and processing fish to generate local nutritional and economic gains. Support from governments should also include: cohesive and comprehensive policies and guidance to promote responsible aquaculture including generous measures for mitigating impacts of climate change to small-holder aquaculture livelihoods initiatives; development and implementation of supervised micro-financing schemes for small-holder aquaculture entrepreneurs; and aggregation of small-scale producers to facilitate participation in market and trade.

5.2 Good Quality Seeds for Aquaculture

World fisheries production was estimated to have reached 145.1 million MT in 2009 of which 55.1 million MT came from aquaculture (FAO, 2010). In addition to China, the major contributors to global aquaculture production from Southeast Asia are Vietnam, Indonesia, Thailand, Philippines, and Myanmar. Production from Asian aquaculture accounted for about 89% of world's production from aquaculture. Although noted to be a relatively young food production sector, annual aquaculture production has rapidly increased from 1.0 million MT to 50.2 million MT after six decades (FAO, 2010). Aquaculture production covers not only freshwater and marine fishes, crustacean and molluscan species but also includes aquatic plants, mostly seaweeds. Breeding and culture requirements for most of the commercially important aquaculture species especially those found in freshwater environments have been well studied (Siriwardena, 2007) thus accounting for a steady growth in production. Ironically though, in many Asian countries, several species that are economically valuable are not indigenous. Tilapia for instance, is a major national aquaculture product in the Philippines, Indonesia, Thailand, Malaysia, and China. In the last five years, apart from tilapia, the whiteleg shrimp (*Penaeus vannamei*) from the U.S.A. became a major culture species in Southeast Asia replacing the black tiger shrimp (*P. monodon*). The interest in whiteleg shrimp can be attributed to the fact that the shrimp industry was in need of a species which when cultured, can earn profits that may be enough to compensate for the losses in tiger shrimp production brought about by disease problems.

5.2.1 Status of Seed Production

Aquaculture production is mainly reliant on seed availability. Seedstocks for the aquaculture of different species could be obtained from the wild or from captive stocks in hatcheries (**Appendix 2**). For species with undetermined or no established breeding technologies, and possibly low seed production capabilities, the source of seedstock will be a limiting factor as commercial production would depend entirely on wild seeds. Seed production is primarily affected by several factors, from genetic to non-genetic or extrinsic causes such as the presence of diseases and sub-optimal hatchery and nursery methods or extreme changes in the environment. However, low seed production in the hatchery can be improved particularly if appropriate interventions are made. For some species such as catfish in Cambodia, milkfish and grouper in Indonesia, tilapia in the Philippines and Malaysia, grouper and sea bass in Thailand as well as in Vietnam, and shrimp in Malaysia, Myanmar and Vietnam, aquaculture production is constrained by seed supply and quality (Hishamunda *et al*,. 2009).

5.2.2 Issues and Concerns

A logical solution to the issue of decreasing aquaculture yield caused by poor survival and slow growth is to use good quality seedstocks. Quality seeds are fish fingerlings, crustacean post-larvae, molluscan spats or aquatic plantlets that are robust or hardy apart from having the same beneficial traits such as the capacity to grow fast, tolerate stress and feed efficiently as the case may be. Good quality seeds can be intentionally produced through the use of good quality spawners; suitable broodstock maturation diets; appropriate broodstock management methods that can minimize inbreeding; conventional selection such as hybridization, mass selection, within family and family selection, or combined selection; genetic manipulation methods; and improved hatchery and nursery rearing protocols.

For aquaculture in the Southeast Asian region, genetic methods have been employed through major selective breeding programs and several of these technologies have been known to generate improved stocks that are either in the process of field testing or have already been disseminated. For example, the Nile and red tilapias, some carps, Clariid catfishes, penaied shrimps, abalone and seaweed species have been the subject of genetic improvement research in Asia although in varying levels of development and adoption (**Appendix 3**).

Nevertheless, some countries have considered genetics as an important component in improving quality of seeds and as such have designated national genetic improvement centers to undertake research to further improve aquatic breeds. Indonesia for one, has assigned institutes specific to species, *e.g.* Sukabumi Aquaculture Development Center and Bogor Research Institute for Freshwater Aquaculture are designated to do genetics research on tilapia, catfish, carp and gourami, and other centers to engage in grouper, seaweeds and tiger shrimp improvement. Apart from these research centers, broodstock multiplication centers and a nucleus breeding center especially for non-indigenous species such as the whiteleg shrimp have also been established mainly to reduce dependence on imported broodstock (Sugama, 2011). Except for tilapia, the impact of the numerous genetic programs that aimed to develop growth-enhanced, stress tolerant and/or disease resistant species have yet to be evaluated in terms of their direct impact on increased aquaculture production and the gains derived from using the improved seedstocks on commercial farming need to be quantified.

It is recognized that improved reproduction and consequently, good quality seedstock are likewise achieved by nutritional intervention. SEAFDEC/AQD through its numerous research and verification studies involving fish and shrimp feed development, has determined the nutritional requirements in the formulation of fish/crustacean broodstock diets that promote enhanced reproduction. This also contributes further to the fact that apart from genetics, appropriate or best management protocols or the adoption of optimal husbandry techniques for rearing potential broodstock as well as for hatchery and nursery operations also help improve seed yield and quality.

5.2.3 Challenges and Future Direction

Aquaculture seedstock are produced by both public and private hatcheries. In many Southeast Asian countries, fish and prawn hatcheries are normally based on small- and backyard- scale operations (Tayamen, 2007). Traders serve as the link between farmers and hatchery operators where often when the seedstocks available from one hatchery do not meet the requirements or demand from prospective grow-out farmers, the trader procures seedstocks from various sources. This arrangement inevitably affects seed quality as seeds would come from different farms and subsequently on-farm performance and yield would not be what the farmer would expect. To ensure quality of seeds that would be in compliance with industry standards, seed certification standards should be defined and imposed, a concern which some governments in Southeast Asia are now trying to address. Countries like the Philippines, still need to formulate and implement seed certification standards while Vietnam and Indonesia, have been imposing regulations to ensure seed quality. Hatcheries such as those operated by large-scale investors, implement strict seed quality standards and dissemination schemes as required by genetically enhanced stocks. In addition to seed standards, these farms follow biosecurity measures on-farm, and this is especially true for disease-resistant and disease-free shrimp seedstock. Ideally, to protect the genetic integrity of premium seedstocks developed through known genetic improvement programs, grow-out farms which receive the improved seedstock would need to ensure that there would be no other unselected stocks on-farm to avoid unintentional mixing of seedstocks for culture. One of the main challenges in the production and distribution of quality seedstocks would be keeping the genetic quality and integrity of the seeds used in aquaculture (Romana-Eguia and de Jesus-Ayson, 2011) and addressing most of the problems in the development and production of quality seedstocks in the Southeast Asian region (**Appendix 4**).

As reported, an estimated 10% of the seedstocks used in aquaculture technically come from known genetically enhanced stocks. The lack of better seeds or lack of access to the same could either be due to flaws in the distribution chain in that farmers still have limited access to genetically improved seedstocks. It is also possible that knowledge about potential sources of good stocks or strains, optimal breeding, hatchery and nursery methods, selective breeding techniques or simply efficient broodstock management schemes to maintain genetic integrity in farm stocks, has not reached the farmers who are the ultimate end users. One way of addressing these issues would be to build and/or further strengthen public-private sector partnerships. Establishing and maintaining links among all the major players in the seed production and distribution chain would basically be part of the responsibility of national governments.

Grow-out operators who can afford the better seeds which are sold at premium prices can choose to get them from private/commercial hatcheries that are able to adopt advanced genetic technologies. Meanwhile, both small-scale farmers and hatchery operators can seek the assistance of the government for capacity building to facilitate farmers' adoption of new simple technologies, access to quality broodstock and seeds produced through farmer-friendly broodstock management methods, and establishment of effective distribution links or channels to enable continuous production and profitable dissemination of better seeds (Mair, 2002).

Finally, the best way to proceed would be for scientists to pursue research on existing genetic resources, particularly on how to improve the seeds to be used in aquaculture. For all the key players, from researchers, individual farmers and farmer clusters, academic organizations, industry and governments, there is a need to establish links to collectively address genetic issues, support sound policies and promote the implementation of better farm management practices to improve the supply of quality seeds and sustain aquatic food production in the region (Little *et al*., 2004; Little *et al*., 2007; Siriwardena 2007).